1886.

PROCEEDINGS

OF THE

UNITED STATES

NAVAL INSTITUTE.

VOLUME XII.

PUBLISHED QUARTERLY BY THE INSTITUTE.
ANNAPOLIS, MD.

PRESS OF ISAAC FRIEDENWALD,
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UNITED STATES NAVAL INSTITUTE.

Vol. XII., No. 1. **1886.** **Whole No. 36.**

WASHINGTON BRANCH, NAVAL INSTITUTE.

DECEMBER 4, 1885.

REAR ADMIRAL THORNTON A. JENKINS, U. S. N., in the Chair.

ANNUAL ADDRESS.

THE NAVY AND ITS PROSPECTS OF REHABILITATION.

By REAR-ADMIRAL EDWARD SIMPSON, U. S. N., President of the Institute.

Ever since I received the notification that I had been elected the President of this Institute for the ensuing year, I have had a desire to acknowledge the compliment, and to express my appreciation of the honor that you have done me in associating me with the distinguished officers who preceded me in this office. It occurred to me that the most fitting and appropriate method of doing this, and at the same time of showing my interest in the Institute, would be to prepare a paper to be read at one of the meetings, or to be published in our Proceedings. The range of subjects to choose from is very wide, for, as this Institute has to do with matters pertaining to the Navy, it is hard to indicate any subject known to modern progress that would not be appropriate; but I concluded to confine myself to no one of these, but rather to assume the position of an observer of

what is now transpiring, to suggest what seems to me to be needful, and to consider the prospects that are held out in the way of rehabilitation of the Navy.

I am aware that in making an address I am departing from custom, but I am willing to endure the penalty that is imposed for the sake of putting before you some ideas which I could not find a more convenient method of presenting. I have been employed lately on duties relating to ships and gun foundries, which afforded me opportunities for observation, and naturally encouraged thought; and it occurred to me that remarks on these subjects, and ideas resulting from the study of them, could not be altogether without profit, and might be found interesting. I, accordingly, devote much of my space to these two subjects, avoiding in the latter, gun foundries, a repetition of what you have read in the report of the Gun Foundry Board, but supplementing what is therein stated by some explanations, which can be familiar only to those who were members of the Board.

I was the more inclined to address you in this manner from the fact that your notice of me and my work comes at the time when, for reasons beyond my control, I am about to be retired from active service, and will be for the rest of my life only "a looker-on in Vienna," and it is for me a suitable time to sum up accounts and, as it were, to take an account of stock.

My first associations with the Navy were nearly 46 years ago. It then occupied a very creditable position, but I saw it advance to its zenith when its ships were the models for the imitation of the world, and its guns were the standard of excellence. I have seen it in its decline until its *materiel* has reached the point where it can be cited as the standard of inefficiency. Even our own daily press make it a target for its shafts of ridicule. Thanks to the Naval Academy and the abiding high tone of the service, its personnel is above reproach, and, in this day of the decadence of our ships and guns, it finds itself equipped for the trying work now before it.

This condition of preparation is the result of the training of officers at the Academy, where the door of knowledge was opened to them, and to their own individual efforts to advance in the studies inaugurated at that institution. This Institute is one of the proofs of the aspiration for advancement that felt the need of a field in which to exhibit prowess, and these efforts have been continued under a pressure that seemed to forbid any chance of encouragement. This element of success we were not favored with for many years; but let

us view the outlook of to-day, let us see if we have not now a right to feel encouraged, and to believe that the tide, having reached its lowest ebb, is now on the flood on which we may rise to the position we once held.

The first and most important consideration for a Navy are ships! A reference to our Navy List shows a beggarly account. What encouragement have we for the future? We have much encouragement, and I will trace with historical precision the progress that has been made, slowly indeed but surely, in this direction.

The origin of the effort dates from June, 1881, when the Hon. William H. Hunt, Secretary of the Navy, appointed an Advisory Board to consider and to report on the need of appropriate vessels for the Navy. This board, styled the first Advisory Board, decided that for all purposes of "surveying, deep-sea sounding, protection and advancement of American commerce, exploration, the protection of American life and property endangered by wars between foreign countries, and service in support of American policy in matters where foreign governments are concerned," and for providing a "reserve of sufficient strength to maintain the effectiveness of the fleet," the United States Navy should comprise 70 unarmored cruisers.

The Board in its report of November 7, 1881, stated that there were 32 vessels in the Navy fit for service. The required 38 vessels were classed as follows, viz.:

Two first-rate steel double-decked unarmored cruisers, having a displacement of about 5873 tons, an average speed of 15 knots, and a battery of four VIII.-inch and twenty-one VI.-inch guns; cost $3,560,000.

Six first-rate steel double-decked unarmored cruisers, having a displacement of about 4560 tons, an average sea speed of 14 knots, and a battery of four VIII.-inch guns and fifteen VI.-inch guns; cost $8,532,000.

Ten second-rate steel single-decked unarmored cruisers, having a displacement of about 3043 tons, an average sea speed of 13 knots, and a battery of twelve VI.-inch guns; cost $9,300,000.

Twenty fourth-rate wooden cruisers, having a displacement of about 793 tons, an average sea speed of 10 knots, and a battery of one V.-inch and two 60-pounders; cost $4,360,000.

In addition to these cruisers, it was recommended to build five steel rams of about 2000 tons displacement, and an average sea speed of 13 knots; cost $2,500,000.

Five torpedo gunboats of about 450 tons displacement, and a maximum sea speed of not less than 13 knots, and one heavy powered rifled gun; cost $725,000.

Ten cruising torpedo boats, about 100 feet long, having a maximum speed of not less than 21 knots an hour; cost $380,000.

Ten harbor torpedo boats, about 70 feet long, having a maximum speed of not less than 17 knots per hour; cost $250,000.

The Board stated that "iron-clads are absolutely needed for the defence of the country in time of war," but as its orders were to recommend means of providing for the present "exigencies of the Navy," it considered this type outside of the category of vessels it was ordered to consider.

In the naval appropriation bill approved August 5, 1882, authority was given to build one each of the first two types enumerated above, and an Advisory Board (the second) was provided to advise and assist the Secretary of the Navy in all matters relating to their construction, and "to prepare plans, drawings and specifications of vessels, their machinery and armament, recommended by the late Naval Advisory Board not authorized to be built."

The second Advisory Board was organized November 13, 1882, previous to which there had been issued from the Navy Department notice and advertisements concerning the construction of the two steel cruisers inviting "all engineers and mechanics of established reputation, and all reputable manufacturers of vessels, steam engines, boilers or ordnance engaged in the business, all officers of the Navy, especially naval constructors, steam engineers and ordnance officers, having plans, models or designs of any vessels, or of any parts thereof, of the classes authorized by the Naval Appropriation Act of Congress of August 5, 1882, to submit such plans, models and designs to the Naval Advisory Board directed to be organized by the Secretary of the Navy, under the provisions of said act, for his advice and assistance in designing and constructing said vessels, in order that the same may be examined by said Board in accordance with the provisions of said act."

The Board issued a circular November 25, 1882, suggesting the general features for the larger vessel authorized to be built for the guidance of those proposing to submit plans.

The Board recommended to the Secretary of the Navy, November 21, 1882, that, in addition to the two cruisers already authorized to be built, there should also be constructed two of the ten second-rate

single-deck steel unarmored cruisers recommended by the first Advisory Board; also one dispatch boat.

On January 2, 1883, the Secretary of the Navy recommended to Congress (in accordance with the advice of the Advisory Board) the construction of one steel cruiser of about 4000 tons displacement, three steel cruisers of about 2500 tons displacement, one dispatch boat of 1500 tons displacement, and one cruising torpedo boat, to cost $38,000. The largest cruiser previously authorized was omitted for sufficient reasons, as she could not be built on the sum appropriated, and it was not considered judicious to build so large and expensive a vessel, which is not required, and which would be very expensive to retain in commission.

On February 1, 1883, the Board submitted general features for a 4300 tons cruiser, and on February 5, 1883, the Secretary of the Navy issued the same to ship builders and engine builders in the United States likely to make proposals for construction.

Congress, in the Naval Appropriation Bill approved March 3, 1883, provided for the construction of one cruiser of 4500 tons displacement (Chicago), two of 3000 tons displacement (Atlanta and Boston), and one dispatch boat of 1500 tons displacement (Dolphin), a portion of the estimated cost being voted at that time, and the balance being provided in the temporary half-year appropriation for the Navy approved July 7, 1884.

The Secretary of the Navy in his report of December 1, 1883, recommended, in accordance with the advice of the Advisory Board, the construction of seven additional steel vessels, viz.: one of each of the three types already under construction by the authority of Congress, and in addition to them, two heavy and two light armed gunboats. The consideration of a bill introduced in Congress in accordance with this recommendation produced an investigation by a Senate Committee, the evidence given at which showed that, with the exception of two of the officers summoned, the Advisory Board had the confidence of the Navy.

This bill failed to pass the House of Representatives. The debate upon it in the Senate was very thorough, and showed that, in that chamber party lines were yielding to what was felt to be a national question.

In the act making appropriation for the Navy, approved March 3, 1885, Congress authorized the construction of four additional vessels, two of not less than 3000 nor more than 5000 tons displacement, costing,

exclusive of armament, not more than one million one hundred thousand dollars each ; one heavily armed gunboat of about 1600 tons displacement, costing, exclusive of armament, not more than five hundred and twenty thousand dollars ; and one light gunboat of about 800 tons displacement, costing, exclusive of armament, not more than two hundred and seventy-five thousand dollars. This bill was passed during the last hour of an expiring Congress, and a line introduced in the House provided that the construction of these vessels should be under the direction of the Navy Department, not subject to the supervision of the Advisory Board. The general features and preliminary plans and calculations have been made for these vessels by a special board on additional vessels, and they are now in the hands of the Bureaus, who are preparing designs on which bids can be made if proposals are issued for their construction by contract.

We thus see that notwithstanding the apathy into which we had fallen, notwithstanding the more serious obstacle of party rivalry, whether with an Advisory Board or without an Advisory Board, the Navy can count on an addition of seven steel cruisers of modern construction, and one dispatch boat as a nucleus for the new navy. The coming year will see four of these vessels completed, and it may be that the year following may launch the four additional vessels ; and have we not a right to believe, that the inertia of rest being overcome, and the energy of motion having been communicated, the pressure of the wave of public opinion will grow in force until it will come to be a recognized necessity to make a yearly appropriation for the increase of the Navy? I think we have a right to believe it. We know that public opinion is with us, the individual legislator will agree to the necessity of the increase; it only remains for the rivalry of parties to be suppressed in the face of this national question, and the signs are greatly in favor of this devoutly wished-for consummation.

It will be noticed that the Act of Congress which originated the first action in this matter was founded upon the recommendation of the first Advisory Board, and it is natural to suppose that the report of that Board will be referred to in future steps that may be taken, and if later experience does not suggest modifications, that they will form the basis for future action. We may thus conclude that the number of vessels indicated by that Board as sufficient to perform the duties of a navy in time of peace will be adhered to, and that seventy unarmored cruisers of steel will in course of time be added

to the Navy list. I count the whole number of cruisers of steel, because, even at a much faster rate than that at which we propose to build, our present supply of wooden ships will have entirely disappeared before that number will be completed.

It will also be noticed that the first Advisory Board interpreting its instructions ("to provide for present exigencies of the navy"), not to apply to armored vessels, made no recommendations as to the construction of such vessels, merely noting that "iron-clads are absolutely needed for the defence of the country in time of war." It seems to me that this is a weak position for us to continue to hold, that is, if the practical working out of the idea is to postpone the construction of armored vessels until we shall have provided ourselves with the seventy unarmored cruisers needed for current use. This is a short-sighted view to take of the matter. There is no good reason why the building of both armored and unarmored vessels should not be prosecuted at the same time; in fact, I think, it can be shown that the construction of the two classes of vessels at the same time would prove ultimately to be economical in result. But, apart from the matter of cost, does it not seem absurd to confine our preparations only to what is required in peace when it is openly recognized that the *armored* vessels are indispensable in time of war?

ARMORED VESSELS.

This view was actually taken of the subject by Senators when the bill for additional vessels was under consideration in the Senate in 1884. One Senator who declined to vote for the additional unarmored cruisers declared that he would vote fifty millions for vessels capable of contending with first-class iron-clads and of resisting modern artillery.

Taking advantage of this offer of the Senator, and with the earnest desire to give him a chance to vote his fifty millions, I addressed a letter to the Secretary of the Navy, which I place here on record as I find it embodies ideas and recommendations which I still hold to be sound. The letter was as follows:

NAVY DEPARTMENT, WASHINGTON, *April* 11, 1884.

The Honorable W. E. CHANDLER,
Secretary of the Navy.

SIR:—Referring to the debate in the Senate on the amendments to the Naval Appropriation Bill, objection is raised by some Senators to granting additional vessels to the Navy on the ground that the cruisers asked for are not of such

fighting quality as to match armored vessels of other nations, the inference being that if a bill were presented for the construction of an armored vessel it would meet with their approval.

The first Advisory Board was fully sensible of the need of armored vessels for the Navy, but in consideration of the great need of cruisers to carry the flag abroad it recommended as the first step in rehabilitating the Navy the construction of vessels to supply this, the most pressing want of the service. Construction of armored vessels was confidently expected to follow in due order after a sufficient number of unarmored vessels should have been built to form a cruising force. It seems apparent that the building of armored vessels, and of unarmored vessels, was not roposed to be carried on simultaneously, from a disinclination to call for very large appropriations.

For the purpose of conforming to the implied desires of Senators for armored ships, and from the fact that there is no doubt of the need of them, I respectfully recommend that the programme laid out by the first Advisory Board be so far departed from as to admit of having one armored vessel under construction constantly, even while the work of providing cruisers is in progress.

The length of time required for such constructions is from three to five years. They are very costly, and will involve much study and careful preparation; besides the selection of a type will be a matter requiring much deliberation.

In relation to the last point, the selection of a type, I submit general dimensions and some particulars of two armored vessels which represent the most advanced ideas of the present day. One of these would, most probably, be the character of the vessel that would be recommended by such a body as the Advisory Board.

H. B. M. Ship Imperieuse, not yet completed, was commenced in 1881. She is called an armored cruiser, and is intended for sea service on foreign stations where fast unarmored ships may have to be opposed, and where second-class ironclads may have to be engaged. Her dimensions are as follows:

Length,	315 feet.
Beam,	61
Draught,	25
Displacement,	7400 tons.
I. H. Power,	8000
Speed,	16 knots.

The battery will consist of four 9.2-inch guns, each mounted in an armored barbette, and six 6-inch guns in broadside. The barbettes are arranged one forward and one aft, and the others abreast of each other at the sides amidships; the heavy guns are thus situated at twice the height from the water that they would be in a turreted vessel, and can be fired three together in any direction. The speed and armament here described does not greatly exceed that of the Chicago, but the difference in displacement of 2900 tons admits of the following armor:

Throughout the length occupied by the machinery and boilers (139 feet), the sides are protected by ten inches of compound armor for a depth of eight feet,

the deck over this is one and a half inch thick; bulkheads of plating eight inches thick run athwartship at the forward and after extremities of the side armor, thus forming a citadel enclosing the machinery and boilers. Forward and abaft the citadel, at the level of its lower edges, extends a protective deck three inches thick, sloping downwards to the sides, as in the Boston and Atlanta. The barbettes are seventeen feet in diameter, and are armored with eight inches of steel, which protects the machinery for turning, elevating and loading the gun, and an armored chute leading to below the armored deck makes the passage of ammunition safe and rapid. The pilot tower is protected by ten inches of armor.

Contrasting the protection afforded by the armor above stated with the vulnerability of the Chicago, the advantage of the increased displacement of the Imperieuse becomes apparent.

Another type of vessel that would come up for consideration is the turreted ship Riachuelo, just completed for the Brazilian Government by an English firm on the Thames. Her dimensions are as follows:

Length,	305 feet.
Beam,	52
Draught,	20
Displacement,	5700 tons.
I. H. Power,	6000
Speed,	16 knots.

The armament consists of four 9-inch guns in two turrets, and six 6-inch guns on the upper deck. There is an armor belt of eleven inches thickness covered by a wo-inch deck, and the turrets have ten inches of armor.

The armor protection is by no means so complete as that of the Imperieuse, nor is the arrangement of the battery so effective, but on the other hand, the speed is greater and the displacement is 1700 tons less.

These instances are cited to show that a Board cannot, except after the most careful study and examination, decide upon even the size and general dimensions of an armored vessel best suited for our purposes; therefore, in suggesting the form for an Act of Congress which shall the best carry out the recommendation I make in this communication, and estimating the time for completing the vessel as three years, I would propose that the authority should be given somewhat in the following form:

For the construction of one armored vessel of not exceeding 7500 tons displacement, one million dollars; such vessel to be constructed under the same conditions as prescribed for the construction of the steel cruisers, and its armor and armament procured, at a total cost not to exceed two millions five hundred thousand dollars.

Very respectfully,

E. SIMPSON, *Rear-Admiral.*

This letter was communicated to Senators and found its way into the press. In these days of rapid development we cannot confidently count on adhering for any length of time to what we approve

to-day. The development is still going on, and the advance already made may constrain us to go a step further, but in this matter of type of armored vessel I think we can claim an exception; for I find no reason to change or modify what I wrote in April, 1884, and I am inclined to think that the question is definitely settled between the casemate, barbette and turret. The first type of seagoing armored vessel naturally had the armor disposed on the broadside. The movement commenced in France, in 1858, was followed by England, and continued until their formidable fleets were equipped in this manner. In 1868 the casemate or central battery armored vessels appeared, represented in England by the Hercules and the Sultan, and in France by the Ocêan, the armor being limited to an armored belt at the water line, and the protection of the battery and engines by an armored casemate. In the French ship, however, in addition to the casemate for the central battery, there were introduced four barbettes, one at each of the four corners of the casemate, armored with six and a half inch plates, and mounting in each a gun of fifteen and a half tons weight. The Marengo, Suffren and Friedland quickly followed the Ocêan, with batteries and armor arranged in a similar manner. Since that time the construction of casemate ships has been gradually discontinued in France, and the barbette is now the adopted type, the armor consisting of a water-line protection and an armored deck covering all vital parts, while the vertical tubular passages for the passage of ammunition are strongly protected. Apart from other reasons this arrangement of armor conforms to the necessities arising from the introduction of guns of much increased calibre and weight.

In 1872 the English Admiralty built the Téméraire, in which two guns were mounted en barbette in connection with a central battery; but they did not fully adopt the type until 1882, when the Collingwood was launched. It is evident that the advantages are fully recognized now by the English authorities, for a large number of vessels of this type are now under construction. I cite here the names and displacement of those which are being rapidly pushed to completion, viz.:

Collingwood, ...	of	9,150	tons displacement.
Imperieuse, ...	"	7,390	"
Warspite, ...	"	7,390	"
Howe, ...	"	9,600	"
Rodney, ...	"	9,600	"
Camperdown, ...	"	10,000	"
Benbow, ...	"	10,000	"
Anson, ...	"	10,000	"

This list is sufficient to prove that England thinks the barbette type of armored vessel has come to stay ; such action implies no doubt of the efficiency of the system.

The monster ships of Italy, the Lepanto and the Italia, of 13,898 tons and 13,550 tons displacement, are of the barbette type, and that nation has now under construction three additional vessels of the same type, viz.:

The Ruggiero di Lauria . . .	of 10,045	tons displacement.
Francesco Morosini . . .	" 10,045	"
Andrea Doria	" 10,045	"

Russia has ten barbette ships on her Navy list, and is continuing the construction.

In recommending, then, as I do, the barbette type of ship for our sea-going armored vessels, I think I have the experience of the world to sustain me. No more positive proof can be given of the superior advantages of the system than the practical demonstration given by the nations cited of their faith in it. There is no saving of weight of armor, but the disposition of the weight is radically different from what it is in a ship with casemated battery, and is better arranged to protect all submerged parts of the vessel, the armor deck being extended aft to the stern, thus covering all parts of the steering apparatus, while forward it gives most valuable support to the ram. The only question that could arise in selecting a type would be between the barbette and the turret system, but for sea-going purposes the increased height in the disposition of the battery given by the barbette, as compared with the position of the battery in a turret ship, must be recognized as an advantage hardly to be equalled by any others that the friends of the turret could advance for their type. And even for coast defence, or for harbor defence, the barbette system presents so many advantages that it seems to be possible for it to be substituted for nearly all purposes where the closed turret is now used. This probability increases with the increase of calibre of the guns, for it must be remembered that with the turret system the port is very near the deck, and the blast from the discharge of a 100-ton gun is something tremendous. There is a dearth of experiments on the effect of blast at the muzzle of a gun. They are much needed to assist in the investigation of this very point.

Having stated my conviction that there should be no delay in commencing the construction of armored vessels, and having given you

the reasons for my preference for a particular type of vessel, and believing that type is sufficiently established by the experience of the world to justify us in accepting it as a standard, I submit to you now a few of the general features of such a vessel as I would advise. It is not exclusively my own design; it is evolved from the deliberations of a body of earnest men who considered the question carefully.

I premise by saying that we are restricted as to the displacement of our armored vessels. It is impossible for the United States to utilize such a vessel as is ranked as first-class by other nations; we have not a sufficient depth of water on our bars. It is a question of draught of water. Again, the dimensions of the vessel must be governed by the size of our dry docks; that building at Mare Island is the only one that would admit a first-class ironclad, while those at Boston and Norfolk limit the extreme breadth to about 58 feet. Here is an absolute limit set on two dimensions; and, confining the length to near 300 feet, in order to ensure handiness, it will be found that, combining these with the two other governing qualities of large margin of stability and space for well protected machinery, the maximum displacement will be fixed at about 7000 tons.

The principal dimensions of the hull would be:

Length, ...	320 feet.
Breadth, ...	58 "
Mean load draught, ...	23 "
Load displacement, ...	7300 tons.
Maximum speed in smooth water, . . .	16 knots.

The battery should consist of four X.-inch B. L. R. guns, each mounted *en barbette* within a fixed turret nineteen feet in diameter, one located on each side amidships, and the other two on the middle-line of the upper deck, one forward and one aft; the guns to be protected from machine fire by revolving hoods of 4-inch steel, the axes of the guns of the side turrets to be twenty-one and a half feet, and those of the middle-line turrets twenty-three feet above the load-water line.

Four VI.-inch B. L. R. guns should be mounted on the upper deck protected by circular revolving 4-inch steel shields.

A suitable secondary battery should be carried, consisting of Hotchkiss single-shot guns of 57 and 47 millimeters, and revolving cannon of 37 millimeters, and Gatling guns.

The allowance of ammunition should be 100 rounds for each

X.-inch and each VI.-inch gun, 1500 rounds for each large Hotchkiss gun, and 800 rounds for each 37 mm. gun.

445 tons should be reserved for the weight of ordnance.

There should be separate magazines and shell rooms for each turret.

The hull should be built of mild steel with brass stem, stern post and rudder should be cased with wood to the height of the main deck and sheathed with copper.

The armor protection should consist of a belt eight feet in depth, three and a half feet above and four and a half feet below the load line, extending throughout the length of 150 feet occupied by the machinery and boilers and central magazines, the ends being enclosed by athwartship bulkheads nine inches thick, the thickness of the side armor being ten inches from the top to one foot below the water line, and tapering thence to five inches at the lower edge of the belt.

The armor on the barbette turrets should be seven feet deep and eight inches thick, on the pilot tower five feet deep and six inches thick, on the hoods to barbette guns four inches thick, and on the ammunition tubes to turrets four and a half inches thick.

At the level of the top of the armor belt and throughout its extent there will be an armored deck two inches thick, and before and abaft the armor belt the armor deck is continued to the extremities at the level of the lower edge of the armor belt, or four and a half feet below the load-water line amidships, sloping at the sides, and at the bow to strengthen the ram.

The ship will have such sail power as can be carried on two steel lower masts, to be fitted to carry circular tops for machine guns and extra gaffs or derricks for hoisting torpedo boats.

Provision should be made for carrying and launching two sixty feet torpedo boats in addition to the usual allowance of boats, and the vessel should be designed with reference to being ultimately fitted with above-water launching gear, in four places, for an automatic fish torpedo.

The coal supply at load draught should be 500 tons, with bunker capacity for 800 tons; and arrangements should be made to stow provisions for 400 men for 90 days, and other stores for the usual periods.

The engines and boilers should be capable of developing 7500 I. H. P. in the aggregate, during a six hour full power trial, the fuel to be the best semi-bituminous coal.

The fire rooms should be made air-tight, and fitted with centri-

fugal fans of sufficient capacity to maintain therein a pressure above the atmosphere equivalent to a column of $1\frac{1}{2}$ inches of water.

There should be twin screws actuated by two sets of three cylinder direct-acting vertical compound engines, the two engines complete being contained in water-tight compartments, separated by a longitudinal middle line bulkhead.

It is proposed that the steam should be supplied by twelve three-furnace cylindrical boilers, having an aggregate grate surface of 900 square feet.

The total weight of the machinery, boilers and appurtenances, including water in boilers and condensers, all fittings, tools, stores, spare machinery, ready for sea, should not exceed 1400 tons.

This is the vessel recommended to the Secretary of the Navy by the Advisory Board, "a part of which I was."

I believe this ship to be a sound basis to work on. Controlled as we are by nature in the displacement to which we can attain, and satisfied as I am that we have reached the type of vessel that will remain permanent, I see no reason why we should delay commencing the construction of our sea-going armored fleet. This fleet should consist of ten vessels, forming the outer line of defence of the coast in war, always available for operating abroad either in peace or war, and affording a school of practice and instruction in peace to prepare us for war.

COAST DEFENCE VESSELS.

But in addition to sea-going armored vessels, we are sadly deficient in vessels for coast or harbor defence. We have sixteen ports on the Atlantic coast to guard, besides San Francisco and other points on the Pacific coast. For this purpose we require a fleet of heavily armed and armored turreted, or barbette vessels, to cover the coast as a second line of defence, and to concentrate at any time at the point attacked. These vessels should be of moderate speed, but as near invulnerable as possible, and armed with batteries that should be irresistible. Two classes of this type would be needed in order to provide for operations in shallow as well as in deep water. With the experience of others, and our own, we could easily determine upon the general features of suitable vessels for this service. The distinct duty for which these vessels would be designed would be to engage armored vessels; consequently all other considerations would have to yield to protection of the hull and the power of the guns. The heavier class should carry guns of 100 ton weight, and the lighter

class guns of, say, 50 tons weight, and I consider that 25 of such vessels are needed to complete the second line of defence. The lightly armored and indifferently armed monitors that we now have on the Navy list can be utilized in the third line of defence until more suitable vessels can be provided, and, in concert with systems of torpedoes, will serve as the defence for harbors and mouths of rivers.

I think that it is very desirable that the construction of the coast defence vessels should go on at the same time with that of the unarmored and armored cruisers. There is no sufficient reason for delaying in either case. As all will be ultimately needed, it is poor policy to delay the work on one until it is completed on others. The navy-yards are idle; no more suitable work can be found for them than the construction of armored vessels. The ship-building interests of the country are at a standstill; no more appropriate or congenial work can they find to fill up the interval of stagnation than the building of unarmored cruisers. The work would give occupation to tens of thousands of mechanics and laborers, and new industries would be started in the country.

In this connection it is proper to put prominently to the fore the absolute necessity of completing at once the four double-turreted monitors, which lie in an unfinished state at the yards of the contractors. These vessels have been assailed for one reason or another, and the effort has been made to impair confidence in them. I know not how far these efforts have influenced the mind of the Navy, but in order to clear up any doubts that may exist I will quote from a report made by the Advisory Board, in October, 1883, in which the Board states its reasons for recommending the immediate completion of the ships.

The Board says: "It is our opinion that it would be wise and expedient to finish the vessels at once, and for the following reasons, viz.:

"1st. The hulls as they are at present are of excellent workmanship, fully up to the present standard condition of iron-ship construction whilst the flotation of the Puritan and the behavior of the Miantonomoh at sea confirm the correctness of the calculations of the designs.

"2d. It is easily possible to complete the vessels by taking advantage of the recent developments in armor, guns, and machinery, without making any radical changes in the designs, so that their

speed, endurance, battery power, protection, and sea-going qualities shall be fully equal to those of any foreign ironclad of similar dimensions designed previous to 1879.

"3d. The vessels may be finished so as to develop all the above-mentioned advantages without making their total cost when completed in any way exorbitant compared with the results obtained; again, the interests of our seacoast defence require a force at least equal to that which would be represented by these vessels.

"We take the liberty of calling your attention to a certain erroneous impression which now exists with regard to these vessels. In one of the official reports on these hulls a doubt was thrown upon the correctness of the calculations of the Puritan. This doubt has spread in the public mind until it includes all the ships. The actual flotation of the Puritan and the Miantonomah proves beyond question not only the reliability of the calculations, but also that the hulls of these vessels are lighter in proportion to the total displacement than those of any ironclad low freeboard hulls afloat, with but two exceptions.

It has been the unfortunate custom, in arguments as to the value of the results to be obtained, to compare them with such foreign ships as the Inflexible and Duilio to the evident disadvantage of the monitors, no account whatever being taken of the fact that these vessels are double the size of the monitors. If these hulls be compared with foreign ones of similar dimensions no such disparity will appear."

Here I close the extract from the report of the Advisory Board. This statement should set at rest all doubts as to the efficiency of the vessels, and the work should be resumed on them with view to their completion at the earliest practicable moment. It is well to add that five other Boards have made similar reports recommending the completion of the vessels.

These vessels, with the exception of the Monadnock, have their machinery in place, and are finished as to their hulls, except the interior fittings, side armor, and turrets.

The estimated cost to complete them is as follows:

Puritan,	$1,141,481
Terror,	785,267
Amphitrite,	797,563
Monadnock,	1,074,069
Total to complete,	$3,798,380

TRAINING VESSELS.

Before dismissing the subject of ships, I should mention a serious want of the Navy in the lack of suitable sailing vessels for training boys and for the exercise of naval cadets in practical seamanship. The system for training boys for the Navy is now established on a basis that seems to work satisfactorily, but, singular to say, the article that is of the very first consequence is that in which we are the most deficient. The few remaining sailing vessels of the Navy are devoted to this duty, but they are so old and are so constantly in need of repair that in a year or two they also will be withdrawn from service. At best, however, they are inefficient vessels, particularly in consequence of the size of their spars and weight of sails; they are too large and heavy to be handled by boys. This objection also obtains in the case of the vessels assigned to the naval cadets. The Naval Academy and the Training School should both be provided with ships of the Dale class, composite built, full-rigged. Six of these vessels should at once be provided. They would be launched in a few months at a cost of about $175,000 for each.

Amid the pressure of advanced ideas and the earnest efforts of progress, the basis of a seaman's education should not be forgotten. Seamanship must not be neglected, and it is at an early age that the knowledge must be acquired. All old officers will agree that they learned their seamanship during their midshipman's career. Learned while young, the knowledge will remain for life and will form the source from which we can draw to our aid in all other branches. There is nothing like it for developing the power of resources and the invention of expedients. A seaman is never helpless. If one means fails he will try another. He can work without tools. The sailing of a ship, the handling of spars, the trimming of sails, the hoisting of weights, the stowing of a hold, all give him an instinctive knowledge of practical science, and above all, a seaman trained to a sailing ship acquires a degree of personal confidence which can come from no other source. We may say that we have now no sailing vessels in general service, hence the necessity of more earnest training in this branch before an officer or man is launched into the regular service. A ship combining sail and steam is not a suitable vessel for training purposes for officers or men. Sailing ships, pure and simple, must be applied to this use, or the education will be sadly deficient.

GUNS AND GUN FOUNDRIES.

The gun as the thing of next importance merits attention. How do we stand in respect to this important element, which stamps the character of the ship, and to the efficient working and handling of which all the designs of the constructor and engineer must be accommodated and made subservient?

We are fortunate in one very important point in the matter of the gun wherein our delay in commencing work has proved of advantage to us. We have adopted a type of gun which all agree is the best. There is no difference of opinion among us. We have received the Vavasseur method of construction as the one superior to all others, and we are confirmed in our judgment by that of other nations who, having embarked in other systems, have now abandoned them and accepted that of Mr. Vavasseur. Woolwich has abandoned wrought-iron, and the efforts of the steel manufacturers of England are now put to a severe test to supply steel in masses of sufficient size to answer the demand, and what is now called the Woolwich gun is the Vavasseur gun, so determined by the Ordnance Select Committee. The Krupp construction is also modified so as to include the Vavasseur long jacket; and the French, though yet somewhat divided between the plans of General Dard of the Marine Artillery, and Colonel de Bange, on whose ideas the army guns are constructed, are approaching the Vavasseur standard. The guns that we see slowly progressing at the Washington navy-yard are Vavasseur guns pure and simple.

You all know how much the matter of the gun has occupied my thoughts, and though, for reasons beyond my control, I have not been privileged to direct in any way this arm of the service, you can readily understand what a gratification I enjoy when I see the ideas that I advanced many years ago being carried out and executed by the present accomplished Chief of the Bureau of Naval Ordnance, an officer well fitted to carry forward the work, and with time before him on the active list to perfect it. I sympathize with him in the extra work imposed upon him in having to invent expedients for manufacture instead of having at his disposal a suitable plant. I will review the steps that have been taken to supply this deficiency.

By Act of Congress, approved March 3, 1883, there was established a mixed Board of Army and Navy officers called the Gun Foundry Board, whose duty it was to take into consideration and to report on

the best means of making ourselves independent in the matter of manufacturing modern cannon. It seemed to be a foregone conclusion with the framers of the bill, that the gun to be manufactured was to be of steel, and that this new manufacture could not be performed by the means at the disposal of the country, which had, up to the time of the Act, manufactured guns only of cast-iron. The Board was not called upon to deal with the matter of gun construction; its province was to recommend suitable sites, tools and all apparatus for the manufacture of guns, and to submit the approximate cost. In the early part of its labors the Board could derive no assistance whatever from our own steel manufacturers. They had not taken the matter into consideration, they possessed no tools calculated to do the work required, none such were made in the country, and the capacity of their furnaces and forging apparatus was insufficient to cast the masses or to forge the ingots required. The information required was gained abroad, and I do not propose to repeat to you the contents of the report made on the subject to Congress. The report has been widely circulated in the Navy, and it attracted much attention from the steel manufacturers at home — so much so as to remove the wall of partition that seemed to exist between them and the Board when they were first approached, and to cause them to come forward and assist the Board in the preparation of its supplementary report, which was called for in order to present in detail a method by which the recommendations of the Board in the original report could be made a practical thing. The plan proposed by the Board for putting in execution its recommendations is the basis devised by the business minds of manufacturers on which they will be prepared to offer bids if proposals are issued by the Government. It is on the successful working out of this business arrangement that our hopes of speedy re-armament depend. I will point out the difficulties that encompass the subject, and you then can judge what encouragement we have to hope for a supply of modern guns.

You are aware that the Gun Foundry Board decided that there should be no government foundry. The share of the work of the Government was limited to that comprised in gun factories, one for the Army and one for the Navy, in which is done the finished-boring and turning, rifling, fitting breech apparatus, and assembling parts; all work of foundry proper, including casting, forging, rough-boring and turning and tempering was relegated to the private industries of the country. There is no question of the inability of any foundry in the United States

to perform the work required. Mr. Sellers, of the Midvale Works, near Philadelphia, has succeeded in supplying some tubes for VI.-inch guns, and the Cambria Works, at Johnstown, Pa., have undertaken to make some hoops, but this is all that can be achieved by their limited equipment. The limitation in the case of the Cambria Works applies only to its forging, boring and turning apparatus. It possesses furnace capacity for casting the largest ingots required for cannon. A manufacturer undertaking the work of supplying the material for all classes of guns must erect a suitable plant.

The cost of the plant is stated as follows, taken from the report of the Gun Foundry Board :

Casting, ...	$250,000
Forging (hydraulic press), ...	150,000
Rough-boring and turning, ...	210,000
Tempering, ...	50,000
	660,000
Additional cost if liquid compression be adopted, ...	175,000
	$835,000

The cost is based upon prices abroad ; in round numbers the manufacturer must expect to invest one million dollars in a plant. He cannot expect to do this unless he is satisfied that it can be kept in operation for a certain time sufficient to remunerate him.

It is also necessary that the time during which the plant would be employed should be continuous, and this must be assured, for the purpose of avoiding the uncertainty attending annual appropriations which depend upon the will of each Congress to be continued or withheld. It thus becomes necessary that a lump sum should be secured for this purpose, which would stand for a guarantee for the execution of such contract as might be made. The question, then, was what sum of money was necessary to appropriate in order to secure the contractors, and assure a supply of ordnance for the government.

The necessary outlay being so large, and the Government desiring only to treat with the most responsible parties, it seemed reasonable to suppose that those embarking in the work would be very few in number, probably but two establishments would take it up, one for the Army and one for the Navy. On this supposition the calculation was made on a unit of works, that is, to find the amount sufficient to induce one establishment to go into the business.

An output of 2000 tons of forgings per year was taken as a basis for production. It was estimated that the average price of the steel would be twenty-five cents per pound, some more, some less; this gave $559 as the cost per ton of 2240 pounds. At this price the cost of the yearly production of 2000 tons would be $1,118,000. Allow, as a fair profit to the business, 15 per cent. of this amount, and we will have for yearly profit the sum of $167,700; and continuing this for six years and a half, the profits will amount to $1,090,050, a little more than the amount of the original outlay. The lump sum required to be appropriated for this purpose would be six and a half times the amount of the cost of the yearly production, or $7,367,000. This agrees with the report of the Gun Foundry Board, in which you will notice that the sum mentioned as necessary to be appropriated is $15,000,000, one-half for the Army, one-half for the Navy, that is $7,500,000 for each arm of the service, such amount being sufficient to secure the supply of material, at the same time assuring the contractor of a fair remuneration. This explains the figures given in the report of the Board.

I call your attention now to the wording of the proposals recommended to be issued for this work. "Said proposals shall divide the steel required into two lots. Each lot shall include all the parts for one-half of the number of guns for each calibre; each bid must include all of a lot or lots."

You see that, though the calculations for cost were made on the basis of a unit of works, there is nothing in the proposal favoring a monopoly in the work. Several manufacturers may bid, and the work be thus divided; this would result only in a more remote remuneration for their outlay. But the Board takes the precaution to require that in bidding for a lot or lots the contractor shall undertake to supply all the parts of the lot for which he bids; this ensures that his works shall be thoroughly equipped for the work he takes in hand. It would be a want of foresight to arrange the lots so that a few small establishments could bid for all the small parts, leaving only the heavy work to be done by those establishments who are willing to bear the expense of erecting a large plant. It is all important to the country as a means of national defence that these large plants should be erected, and all means should be taken by the Government to encourage the work; thus, by requiring all parts of the gun material to be included in a lot, an advantage is given to those establishments which propose to make their plants complete.

Supposing contracts to be made for the material, you may accept the period of delivery, stated in the Board's recommendations relative to proposals, as deserving of all confidence. It required that "Each bidder shall agree to deliver yearly a specified quantity of each calibre, the time of delivery of the smaller calibres to commence at the expiration of not more than eighteen months, and that of the largest calibres at the expiration of not more than three years from the date of the acceptance of the contract." This estimate is determined by positive information on the time necessary to duplicate the best tools now in use at the largest foundries abroad. The supply of the plants is an affair that would be entirely in the hands of the manufacturers themselves, who would naturally consult their own interests in equipping their establishments; it would be for them to choose between adopting tools of approved utility purchased abroad or encouraging home manufacture and risking failure by undertaking the work with the first productions of a new industry. There can be little doubt that, being bound by contract as to the time of delivery of the production of their works, they would wish to commence operations with tools of well-known capacity; the home manufacture would naturally follow, and would, no doubt, improve on the standard, but it would be a great risk at the inception of the manufacture to work with untried implements. The time for delivery of the productions of the foundries is predicated upon the supposition that the first tools used will be bought abroad, and upon the known capacity of such tools to turn out a certain amount of work in a given time. On any other basis, the time of delivery would have to be indefinitely extended, in fact there would be no data on which to make a calculation. So much for the foundry work.

It is manifest that the delivery of the tempered material for guns, rough-bored and turned, is of no avail unless the gun factories are prepared to take the parts as they arrive, and to smooth-finish and assemble them. These indispensable establishments must be organized while the material is in course of manufacture.

The cost of a plant for a gun factory is given as follows by the Gun Foundry Board:

Guns up to VI.-inch calibre, ...	$50,000
" from VI.-inch to XII.-inch calibre, . . .	150,000
" " XII.-inch to XVI.-inch calibre, . .	350,000
Buildings and shrinking pit, ...	350,000
	$900,000

"Three years will be required to complete the tools, construct the shops, and establish the plant."

This period is intended to represent the time necessary to complete the factory, equipped for the fabrication of cannon of all calibres up to the largest available for warfare. The building and the tools required for the smaller calibres, including those for VIII.-inch guns, could be prepared in less time. The building, for example, could be erected in one year, and the smaller tools could be delivered and put in place in a year and a half, which, you will notice, is precisely the period of time required for the commencement of the delivery of the material for the smaller guns. Thus the time for the delivery of the material and the time when the factory would be ready to receive it synchronize, and if the authority to erect the factory be given at the same time as the contract for the manufacture of material the work will go on harmoniously from the commencement. It is evident that the two operations must be regarded as necessary parts of one transaction; one is of no practical use without the other. In the case of the gun factory, as in the case of the foundry, I have to state that the cost of tools is predicated on prices obtained abroad, and the time of their delivery on what is known as the period required for duplicating those in use in England, France and Russia.

I hope that the practical thoroughness of the report of the Gun Foundry Board is appreciated by the services. I make this remark before a naval meeting in order to point to our indebtedness to our brothers of the Army, with whom we share the credit of the work.

We thus see that, if during the approaching session of Congress, there should be enacted all the legislation necessary to equip the two arms of the service with modern ordnance, and if the steel manufacturers should respond to the proposals of the Government, it would not be before the early part of 1888 that we would be able to commence the fabrication of the smaller guns at the factories, and not until a year and a half after that that we would be ready to take in hand the guns of the largest calibre. It is very evident that, in comparing our chances of speedy acquirements of ships and guns, the ships are the more readily attainable. For their construction we have ship-yards whose plants can be readily supplemented with the additional tools that will be required; but for the fabrication of cannon we have yet to commence the erection of plants and to inaugurate the manufacture of the material. We have the satisfaction of knowing that, since the presentation to Congress of the report of the Gun Foundry

Board, a committee has been appointed in both houses to take into consideration the capacity of the foundries in the United States to provide steel for ships and guns, as well as the capacity of our ship-yards to construct modern ships of war. This action on the part of Congress is a step in the desired direction, and if time be found during the session for the deliberate treatment of national subjects, we may expect that some definite method for advancement may be matured.

ARMOR.

Another sign of encouragement is to be found in the establishment of the "Fortifications Board," on which the Navy is well represented by two members of this Institute. There can be no doubt that this Board will recommend that one line of the coast defence shall consist of armored turreted or barbette vessels, the construction of which would call for a large supply of armor plates. Here we see another powerful reason for the establishment of foundry plants.

If it shall be decided to commence the construction of armored vessels, and to face forts with armor plates, it will be necessary for the Government to make a definite selection between the steel plate and the plate of compound armor. The compound armor, again, is not all of one patent. The Cammel plate, consisting of a previously prepared iron plate on which the steel facing is cast, is all prepared in the rolling mill; the iron plate is rolled to dimensions, and, after the steel facing is placed, it is finished by passing through the rolls. With the Brown compound armor plate, however, the iron plate is prepared as before, but the steel plate for facing is also prepared separately, and this is forged under a hammer. The steel plate being then placed on the iron plate, separated from it by distance pieces, melted steel is poured into the space between the plates, thus welding the one to the other; it is finished by being pressed through the rolls. In this case we find a necessity for the heavy forging hammer or press. The steel plate as manufactured by Mr. Schneider at Le Creuzot is worked entirely under the hammer, is tempered and subjected to other treatment. My own judgment favors the steel plate. I think it more in the course of advanced ideas, and I am content with the results it has achieved in experiments; and the more experience we have in the manufacture, the more will we approach perfection in results. If the steel plate be adopted by the Government, we see how indispensable it is for us to be provided with large forging facilities, whether with the hammer or forging press.

I am aware that at Terre Noire, in France, it is claimed that a good steel armor plate can be cast which needs no forging, and I am under the impression that the same idea obtains at one of our own large steel establishments, but I have no confidence in such material, and I think that the first shot from a modern gun would dispel the illusion of those who entertain the idea. I accept as a fact that for the manufacture of steel armor plates there is required a heavy forging plant, and if we possess such facilities for forging our ingots for cannon we have secured apparatus that will be equally serviceable for treating armor plates.

An approximate calculation will give an idea of the amount of material that would be required for the purpose of the Navy. Supposing that the United States should undertake the rapid construction of an effective ironclad fleet, including armored cruisers and vessels for coast defence, the largest probable rate of construction would not exceed the completion of one armored vessel of 7000 tons displacement, and two of 5000 tons each year. This would require a total annual expenditure of seven and a quarter millions of dollars, and an annual supply of armor of about 3800 tons, including their armor for protective decks and protecting shields for light secondary batteries.

During the first year after the construction is commenced, not more than half this amount of money above estimated would be expended, nor half the armor required. This approximate estimate is made supposing that the amount of armor now carried by modern vessels will continue to be used. In addition to the above supply of armor for new ships, the completion of the double-turreted monitors now on hand would require an immediate supply of 3000 tons.

Nor must we forget the amount of material that would be required to *arm* the ships that I have proposed. There will be required for the batteries of the seventy unarmored cruisers, the ten armored cruisers, and the twenty-five coast-defence vessels about 7000 tons of *guns*, which we may roughly estimate at about 10,000 tons of forgings.

I give these estimates to illustrate the high figure to which the wants of the Navy swell. It is well that we familiarize ourselves with the idea of large masses of material and large expenditures of money; the rehabilitation of the Navy is a work of magnitude, and Congress and the people must be approached without disguise. The steel manufacturers may also recognize their opportunity, and find that their interests lie in supporting our efforts.

TORPEDOES.

Everything relating to torpedoes is legitimate work for the Navy and merits the close attention of this Institute. Although the stationary mine for the defence of the coast is relegated to the Army, yet it is a weapon which we may, either at home or abroad, be called upon to manipulate, and our instruction in it is very thorough at the torpedo station at Newport; but the movable torpedo is the one that more especially demands study and development from us. In seeking for indications of advancement in this field, the difficulties that surround it are impressed upon us by the paucity of the results. The essential requirements are perfect control of direction both vertically and laterally. The Whitehead torpedo is the only one that possesses these attributes sufficiently pronounced to justify its being issued as a war implement. The control of the movements of the torpedo is effected by means of two rudders, the one vertical, controlling the horizontal deviation, which must be permanently set at such an angle as experiments with each torpedo show is necessary to make it go straight, the other horizontal, regulating the immersion, which is actuated by a piston under air pressure governed by the hydrostatic pressure of the surrounding water. The principle on which the latter result is achieved is recognized, but the device itself is only known to the experts of those nations who have paid the price demanded for the information, and its nice adjustment is the result of multitudes of experiments, and the expenditure of large sums of money. The results seem to be very satisfactory, but the control over the lateral deviation of the Whitehead torpedo does not meet all the circumstances of service. I believe I am correct in stating that no confidence can be placed in the operation of it when discharged from the broadside of a vessel moving through the water. When fired ahead or astern the direction is sustained as originated, but its course is very erratic when projected under other conditions.

In this respect the torpedo of Captain Howell, of the U. S. Navy, is much the better equipped, for the power being stored in a fly-wheel revolving in a longitudinal vertical plane, its gyroscopic tendency makes it impossible for the torpedo to deviate from its original course in a horizontal plane. His device for regulating immersion is not yet sufficiently perfected to ensure the required action with certainty. This can only be done by repeated experiments, which must extend over considerable time and involve the expenditure of much money.

Thus far the Government has expended but a few hundred dollars to assist the development of this torpedo, but as its good points are the more appreciated the chance increases of securing liberal aid for experiments. We have good expert opinion for the belief that the Howell torpedo is the successful rival of the Whitehead.

But it is important to note the effects that have been produced by the introduction of the Whitehead torpedo. It has introduced an element into the calculations of war that interfere materially with the conclusions that had been reached on the equipment of ships.

The introduction of the weapon involved that of means to utilize it, and some ships were fitted with tubes from which it could be projected. The next step was the construction of very fast torpedo boats, assigned to ships capable of stowing them, which were expected to be launched at sea to assist in a naval action. The general adoption of this idea has led to the construction of larger vessels having increased speed, which, apart from the destruction they are expected to work by their torpedo attack on large vessels, are designed to act as torpedo boat catchers, and, in addition to their torpedo battery, are fitted for this purpose with a formidable supply of rapid-firing single-shot Hotchkiss and revolving cannon capable of perforating all parts of a torpedo boat.

The French style this type of vessel a "dispatch torpedo boat," and they are represented by the first one of the class called La Bombe, which was launched in August last at Havre. Eight vessels similar to La Bombe are now included in the official list. These vessels measure about 196 feet in length with a draught of water of about six feet, on a displacement of 360 tons. They are built entirely of steel, and care has been taken to make the hull as light as possible, and at the same time strong enough for the navigation of the high seas. They develop about 1800 horse-power of engines, attaining a speed of nearly 18 knots. They have three masts, and are provided with the latest improvements for handling torpedoes, and with apparatus for electric lighting, etc. Hotchkiss single-shot and revolving cannon form the gun battery. The tubes for the Whitehead torpedo are above water on each bow parallel with the keel.

The British Admiralty have prepared designs for this new class of vessels called "torpedo gunboat," and in October last issued proposals for their construction to leading shipbuilders in England. These vessels measure about 200 feet in length, while their displace-

ment with a mean draught of about eight feet will be 450 tons. They are to be built throughout of steel, the decks covered with wood planking. They will have four torpedo-launching tubes, one forward, one aft, and one on each broadside. Their gun armament will include a breech-loading 4-inch gun, and four three-pounder (47 millimeter) rapid-firing guns in addition to the machine-gun armament which it is now usual to supply to torpedo boats. They will be provided with twin screw engines of a total horse-power of about 2700, and the speed expected is from 18½ to 19½ knots. They will have a protective deck of about three-quarters of an inch in thickness, with a protection of coal of about three feet thick around the boilers and machinery.

We see from this what are the constituents of a modern fleet. The armored ships form the line of battle-ships; these are attended by tenders and dispatch boats and by the torpedo boats, which they launch before going into action, and to these are added the torpedo boat catchers whose province it is to destroy the torpedo boats of the enemy with their guns, as well as to operate as occasion may serve with torpedoes against their battle-ships. All of this formidable array of boats and small vessels is now considered necessary for the protection of the battle-ships against the spar and Whitehead torpedoes.

Admiral Hobart, Pacha, who commanded the Turkish fleet during the Turco-Russian war, gives his experience on this subject, and he considers that the power of the torpedo as a weapon of offence as well as of defence is enormously exaggerated. He does not deny the deadly effect of the weapon itself, but he rates the difficulties of successfully applying it very high, and with vessels at anchor he shows most effectively how the attack can be guarded against even with improvised means at the disposal of any well-equipped vessel of war. He anchored his ships in groups of four. These were surrounded by the boats of the vessels, twenty-four in number, which were anchored in a circle and connected together by a wire rope which is buoyed half-way between the boats. The boats are estimated at nine yards in length, the twenty-four spaces between the boats are fifty-four yards each, the radius of the circle described by the boats is five hundred and fifty yards, which keeps them four hundred yards from the ships. The wire rope is supposed to be immersed two feet in the water.

The object of the rope is to catch the screw of any attacking torpedo boat. The Admiral states that "it has been proved that common rope, used for want of anything better, has effectually

checked the career and capsized an attacking torpedo boat in her attempt to destroy a Turkish ship in the Black Sea during the last war; and I know that most satisfactory experiments with the wire rope have been made elsewhere. The result of these experiments was that a torpedo boat, steaming nineteen miles an hour, has capsized while dashing full speed on to an imaginary enemy's ship." An instance is also cited in actual practice where a most gallant and dashing attack made with a spar torpedo was frustrated by this system of guard.

In Admiral Hobart's article he incidentally contributes most important testimony to the ease with which the Whitehead torpedo can be made to deviate laterally from its course. He says: "One of these torpedoes struck the chain of the flag-ship and went on shore unexploded; another struck on the armored belt of a corvette and exploded, but, the blow *being at an angle*, it did no material injury." If we apply this evidence to the comparative directive power of the Whitehead and the Howell torpedo before referred to, we will see that in the two cases cited, where for want of directive power the Whitehead torpedo failed to accomplish any result, the Howell torpedo, possessing this property to an eminent degree, would have resisted the effort to deflect it, and would have achieved its object. This strikes me as very conclusive that it is a necessary requisite for an automatic movable torpedo to have inherent in it a positive directive force, so as to resist efforts calculated to cause deviation. The want of this is a defect which we find in the Whitehead, but we have it in the Howell torpedo as its most essential characteristic. I take much interest in the experiments with the Howell torpedo, and I hope the Government will carry them on on a liberal scale. I have faith in its success.

What has been stated is sufficient to show that there are two sides to the torpedo question, or rather, that the power of attack with the weapon is so much neutralized by means available for defence as to deprive it of the prestige it had acquired before means of defence were inaugurated. In shallow waters or in harbors where stationary mines can be planted or floated at convenient depth of water, they are a sure means of destruction, but with net protection, cordons of boats, secondary batteries and a bright lookout the evidence goes to show that to the present time the effect in offence has been very trifling in result. The great expense, however, of the present battle-ships makes it necessary to guard against all chances of service, and thus

we see that the nations having the most at stake in this matter consider it necessary to protect their fleets with supplementary squadrons of torpedo boats and again with torpedo-boat catchers. Thus far the matter rests much in the realm of theory; it remains for the realities of war to solve many of the questions which are now matters of opinion and discussion.

It will be noticed that in stating the constituents of a modern fleet, no mention is made of the ram. This class of vessel, built with sole purpose of operating the ram unsupported by other weapons, was considered some years ago as a suitable vessel to accompany the battle-ships and to take advantage of the melée to ram the enemy, but advancement in the development of this idea has ceased since the adoption of the torpedo boat. At present we find in the English Navy vessels either turret rams, as the Conqueror and Hero, carrying heavy guns in a single turret, or torpedo rams, as the Polyphemus, with complete facilities for ejecting the torpedoes, and armed with rapid-firing cannon and machine guns for defensive purposes, but no vessel intended to operate solely with the ram. It seems to be conceded that all the useful purposes of a ram can be performed by the fighting vessels themselves, all of which have a powerful permanent ram bow stoutly supported by the horizontal armor deck or armor belt. The first Advisory Board recommended that rams should form a part of our fleet, and the present Advisory Board has submitted the general features for one, but it was found necessary to give the vessel a displacement of 3000 tons so as to ensure a draught of water sufficient to enable the ram to operate below the armor belt of an armored vessel.

In referring to the armaments of the numerous classes of vessels which now form a modern fleet, we find that there are none that do not have a number of machine-revolving and rapid-firing single shot guns as a portion of the battery. So general is this application, that every ship carrying large guns now has two batteries, and in speaking of them they are indicated as the primary and secondary batteries. No modern cruiser or armored vessel would be complete without this secondary battery. They are considered necessary in general action for clearing open decks, for entrance through port-holes and, as their penetration is very satisfactory at long distances, for the damage they can do after perforating the sides of unarmored vessels; they are also handy guns for use in tops, and are indispensable for protection against boat attacks by boarding and by torpedoes. This aid to the primary

battery is regarded as an established provision for a modern battle-ship.

Accepting the correctness of this conclusion as applied to ships armed with modern artillery, how much more does it apply to ships armed with guns which are not fitted to answer the demands of modern warfare?

I was particularly impressed with this conviction during a late visit, on inspection duty, to the U. S. S. Brooklyn, just fitted for sea. I found the old historic ship in good order, well officered and with a young and hearty crew. Although she had been but five days from the navy-yard her organization was complete, and drills were already commenced; but as I stood on her poop-deck and looked down on a fine body of men at their quarters standing by their IX.-inch smooth-bore guns, my mind instinctively jumped to the contemplation of action, and I pictured to myself the scene if engaged with an enemy armed with modern artillery, and with speed that would prevent the Brooklyn from coming to close quarters, the only position in which her battery could be effective. I could recognize no hope in such a contest. The Brooklyn has besides her smooth-bore IX.-inch guns, one VIII.-inch converted rifle, one 60-pounder rifle, and four 37-millimetre Hotchkiss revolving cannon. The first two guns would be moderately effective at long range, but the 37-millimetre guns are only of use to guard the sides of the ship against torpedo boat attack. I felt that here, if anywhere, and more than anywhere else, was a need for the largest rapid-firing single-shot guns. The 57-millimetre Hotchkiss gun throwing a shell of six pounds weight, with a sufficient bursting charge, could be used to great advantage; its penetration at 1000 yards is sufficient to penetrate two inches of iron, and it would, without doubt, perforate the side of any unarmored vessel, and it would give encouragement to the men to feel that there were some means in their power by which they could give back the blows they were receiving.

While we remain in our present helpless condition in respect to our primary batteries, I think that a great effort should be made to increase the power of our secondary batteries; our ships should be supplied with as many of the 57-millimetre Hotchkiss single-shot guns as can be accommodated, and the 47-millimetre guns should be put in the tops. This gun can also be utilized as a boat gun for cutters that are now provided with no boat armament. The 37-millimetre revolving Hotchkiss cannon is undoubtedly the gun most efficient for

repelling boat and torpedo attacks, and the Gatling gun is indispensable for use on shore with landing parties, but for the secondary batteries of ships for purposes of general action, and for the protection and encouragement of men stationed at our smooth-bore guns, we should place in position as many of the largest sized single-shot rapid-firing Hotchkiss guns as can be accommodated.

This involves, I well know, the question of stowage, for the amount of ammunition for these guns must be liberal. Imaginary established rights to space and store-rooms will have to yield to the necessity of the chief want, and much that is now considered necessary in other departments may be found to be superfluous. Fortunately in our old-fashioned ships the aggregate of the space for stowage is ample, and a judicious curtailing of space occupied by other departments will, without doubt, result in accommodating the ammunition required to make the secondary battery effective.

STEAM ENGINEERING.

Equally important with ships and guns are all matters pertaining to steam engineering. Fortunately our coast trade and the navigation of our inland waters has saved us from being unable to build engines and boilers, and in this respect we may feel that we are equipped to such a point as will make only supplementary such improvements as may be found necessary when the reconstruction of the Navy shall assume an earnest character. On this subject, however, I shall allude, with deference, to two matters which I consider well worthy the thought and attention of those charged with the important duty of designing and building our engines and boilers. One is the weight of our engines, the other is the necessity of a new type of steam generators.

In determining the general features of a vessel of war, of a given displacement, the first question is as to the weight of the boilers and engines. If a certain speed is required, and the engineer declares that a certain weight of engines and boilers is necessary to produce it, it must be yielded to him as he is responsible for the horse-power to be developed. The constructor, ordnance and equipment officers must do the best they can with what is left of the displacement. I do not think that sufficient attention has been paid to reducing the weights of our engines. I am the more confirmed in this opinion by the comparison of the weights of engines in ships lately built abroad with those assigned to our vessels of similar displacement.

I am aware that it has been the habit of some engineer officers to read these statements with reserve, to accept them with certain grains of allowance: as, for example, it is said that many things which are entered in the sum of weights with us are not so entered abroad, such as fire-room floors, platforms, ladders, spare parts, etc., all the appurtenances. It is said that the published weights comprise nothing but the actual engines and boilers themselves. I have never investigated the basis on which these reports are made, consequently am in no position to allow or to disprove this assertion, but my mind has never been satisfied that the reason was satisfactory. It seems to me more natural to take the reports as expressing what they purport to do. I believe that by careful study of this detail we can reduce weights; no one will deny that we can reduce weights very much by substituting steel for iron in many parts of our engines, as the superior strength of the steel will allow of very much reduced dimensions.

But how much more can these weights be reduced if a multitubulous boiler be adopted as the steam generator! We are now brought face to face with a positive demand for great speeds; ordinary speed will not satisfy the demands of the times.

This can only be produced by increased power developed at the screw, which means an increased supply of steam to the engines. With the Scotch boiler this means a multiplication of the number of boilers in order to obtain the increased grate surface, and a consequent large increase in the weight of the boilers and water to be carried.

At present, in order to avoid the necessity of carrying so much weight, only made necessary at the highest speeds, abnormal means, as forced draught, have to be resorted to. The fire room is closed, the blowers worked with great violence, and the furnace, combustion chamber, uptake, and smoke-pipe are converted into parts of a blast furnace, the effect of which is to burn up and destroy rapidly all parts that are not surrounded by water. It seems to me that when we have reached the point where it is necessary to destroy the boiler in order to obtain the power demanded, it is time to look for a new steam generator. I am presenting no new idea, but I wish to emphasize the necessity of this effort, and to suggest to this Institute and to the Navy the necessity of action in this matter.

The two more familiar types of multitubulous boilers for sea-going vessels are the Herreshoff and the Belleville boilers. I hazard no description of them; they are familiar to you. They have been going

through a state of probation for several years. Mr. Herreshoff has increased the size of his boats which carry this boiler until he has a vessel of 94 feet in length, 11 feet beam, 28 tons displacement, 4½ feet draught aft and 3 feet forward, with which he has obtained a speed of 21 knots per hour. The French government has experimented with the Belleville boiler, and the performance of the dispatch boat Voltigeur, recounted in a paper published by this Institute in 1883, is well worth attention, for it conveys undeniable testimony of the success of the experiment; and in fact, the trial in May last of the French dispatch boat Milan, of 1560 tons displacement, 303 feet in length, and 33 feet beam, takes the matter out of the region of experiment, and exhibits the Belleville boiler as an accomplished success. This vessel, on a draught of water of 12 feet, has attained a speed of 18.4 knots, with a developed horse-power of 4000.

The Herreshoff and the Belleville are the only tubulous boilers that I know of that have as yet been applied to sea purposes, but we have the Babcock and Wilcox, and the Moore boilers of the same general character and type which are in use for stationary purposes, for heating or for working stationary engines, and no doubt these can be successfully applied to sea purposes by introducing modifications that would be found necessary in the new sphere of usefulness.

I will not attempt to institute comparisons, nor to discuss the details nor proportions of various types of boilers, but wish to emphasize the importance of a careful examination of a subject which promises to produce a safe and desirable marine boiler with a reduction of weight of 30 to 50 per cent. over the Scotch type, thus adding enormously to the total efficiency of a ship.

The designing of a small gunboat is now under consideration at the Navy Department. Her displacement is fixed at 800 tons. If the same conditions obtain as in the cases of proportional weight cited above, nearly one-sixth of this will be devoted to providing for the weights of her boilers and engines, and a tenth to the accommodation of coal, thus appropriating about one-fourth of the entire displacement. This is probably the best that can be done with the present type of boiler. The ever-increasing demand for storage for ordnance supplies, consequent upon the large charges of powder now used, and the space needed for the stowage of ammunition for the secondary batteries, has reduced the equipment outfit to a minimum, has contracted the dimensions of the hold so that provisions can only be

carried for a limited period, and seriously curtails the living spaces for the crew. A lightening of weights must be brought about in every department, and special effort should be made in those appertaining to the engines and boilers. If the law authorizing the new vessels did not preclude anything in the nature of an experiment, I don't hesitate to say that I would like to see the first experiment in this direction made on this new gunboat; if the result were to be a total failure, I should consider it cheap experience. And it is well to mention just here another advantage attending these multitubulous boilers—that there is no trouble in removing them, as they are arranged in sections which can be renewed without tearing the ship to pieces by taking up decks. This concludes what I have to say on this subject. It may be that I underestimate some of the difficulties which I know exist in making this new departure, but in consideration of the advantages that will ensue from a successful application of this steam generator, I think they are worth the effort.

HYDROGRAPHIC OFFICE.

After touching on subjects on which our Navy is deficient, it is a relief to turn to one branch of the service where our advance is not only creditable but promises to equal, if not to surpass, the development of similar work in foreign governments. I allude to the Hydrographic Office.

A large number of officers are connected with this office, but the work is of such a character that it does not force itself so much on the attention of the service as do other branches. Its primary work is to supply our ships with charts and to carry on original surveys out of the waters of the United States; but the duties to effect this are multifarious, and a very perfect organization is necessary in order to guard against errors or oversights which might produce very serious results. This office must be sure that, in distributing charts and sailing directions, it has the latest and most trustworthy information; accuracy is indispensable in the charts by which a ship is navigated. It is customary to place implicit confidence in a chart, unless warned of inaccuracies, and the responsibility of accident falls on the Hydrographic Office if reasonable precautions have been taken by the ship. It is, thus, very important to be able to trace error to its source, and in the organization of this office every precaution is taken to ensure this personal responsibility. It is impossible to assert that no error can occur in any system, how-

ever perfect it may seem to be, and however faithfully the agents may work; but where a system is so arranged that an error is sure to be traced back to the person responsible, there is no doubt that a special guard against inaccuracies has been secured. The checks that are introduced in this respect in the Hydrographic Office secure this personal responsibility and it must inspire much confidence in the work of the office.

The office is in correspondence with all similar institutions in the world, also with our ships of war and the United States consuls in the seaboard countries, and no chart is issued until all known charts of the region have been consulted and all information has been collected from every available source.

At present the larger portion of charts issued to the Navy are purchased abroad, the British Admiralty charts being in the largest proportion. In fact the Navy is practically dependent now on Admiralty charts, which form 85 per cent. of the chart outfit of a cruiser on the European station, 76 per cent. on the Asiatic, 30 per cent. on the Pacific, 40 per cent. on the South Atlantic, and even 25 per cent. on the North Atlantic station. Corrections are being constantly made and new charts purchased, but the ultimate object of the Hydrographic Office must be to make itself independent of foreign purchases, and to equip itself with its own original plates of all the waters of the world. We have only to imagine a state of war to recognize at once the necessity of thus providing ourselves. Of course the plates must be electrotyped for printing purposes, all of which requires time and money. This necessity is recognized by the present accomplished and energetic hydrographer of the Navy, and small sums each year are devoted to this purpose as they can be spared from current expenses, but the work should be separately provided for as a distinct object, and appropriations made accordingly. It must be remembered that this need exists not only for the Navy, but for the merchant marine, which is forced to purchase its foreign charts of dealers, who naturally sell to them charts of old date as long as any of the old stock is on hand.

The number of original plates now in the possession of the Hydrographic Office is about 350, and quite a number of them are electrotyped, but when we consider that the number of charts required for navigating all the waters of the world now reaches over 3000, we see that there is much labor yet in store for the office before we can be considered independent in this matter. All other nations of any

importance are entirely independent in this respect, and the thorough organization that now obtains in our office justifies this consideration for it.

All other details appertaining to such an institution are carefully worked out. Sailing directions always corrected to date and notices to mariners are issued with dispatch, and our consuls abroad are kept informed of all that transpires necessary to be communicated to our merchantmen abroad.

One of the best proofs of the practical value of the Hydrographic Office is the favor with which it is regarded by our merchants and merchant captains. The establishment in our principal seaports of branch offices has had much to do in calling its usefulness into notice. It is found now that ship captains bring their charts to these offices for verification and correction, and many are surprised to find that new editions of their charts showing quite different hydrographic conditions have long since supplanted those which they were using. The notices to mariners, also, which give immediate notice of newly discovered dangers, are thus more rapidly communicated to those who are the most interested in them. The interests of ship captains, thus aroused, works now to the advantage of the office itself, for it is in constant receipt of information communicated by those who have been benefited by its operations. The sale of the hydrographic charts has also increased to a great extent.

A striking feature in the work of this office is the monthly issue of the pilot chart of the North Atlantic Ocean, which presents graphically any information relating to the North Atlantic of interest and value to mariners. There appears on the chart a statement of the information collected during the month preceding and a forecast of what may be expected during the month following. This chart is carried by all Trans-Atlantic steamers, and many of them are sailed in accordance with its instructions. The prevailing winds, the position of icebergs and that of wrecks along this highway of the ocean are items of knowledge much needed by the navigator, and it is expected that the observations now being collected will enable the office, in a short time, to lay down a very close approximate limit of fogs during the different seasons of the year which will be a valuable addition to the present guards against accidents.

We can congratulate ourselves on the creditable and most useful work that is being done by this branch of the Navy Department, and it is to be hoped that our present able hydrographer may be encour-

aged in his work by liberal appropriations to enable him to make the Government independent of foreign aid in the supply of charts.

I have finished the work that I set myself to perform. With the exception of the Hydrographic Office, which I recognize as established on a sound basis and only needing appropriations of money to make it independent of foreign aid, the subjects on which I have touched are those in which we are most deficient. I have confined myself to them as being the essential ones to be borne in mind as needing attention in the work of rehabilitation. The main object of my address is to preach encouragement to those who are left to occupy the field of action. The chance for speedy restoration to the position that the Navy once occupied is not cheering at present, but we have cause for encouragement in the fact that the first steps have been taken, and it is the first step that always costs the most effort. We have the right to recognize that the advance has commenced, and it is the duty of every individual member of the service to prepare to do his share in aiding the movement.

As I said before, notwithstanding the decadence of the *materiel* of the Navy, we have reason to be proud of the condition of its personnel, and we feel confident that it embodies talent capable of treating the many questions of science and practice that are to be encountered. These involve much work and demand thorough knowledge of the subjects to be treated, and I am tempted to emphasize the source from which the Navy, at this time of trial and exacting requirement, draws the strength which enables it to respond to the call made upon it. The source of power is in the Naval Academy which has saved the Navy. The portion of knowledge there acquired has expanded the minds of its graduates, and their habits of study have enabled them to go on and better their instruction. The result has been the wide dissemination in the service of advanced ideas which keep pace with progress and fit the officers for the work they are called upon to perform.

I have the honor of being the senior graduate from the Naval School at Annapolis, but I did not enjoy the advantage of the academic course, which came after my time. I claim it, however, as my Alma Mater, and I take as much pride in it as do those of younger classes; and, in concluding my remarks, I would say to all graduates that, while we cling with affectionate memory to the associations that surround the Academy, and while we love to share

with it the credit that its graduates have achieved, we should not forget him to whom we owe the gift, we should ever keep green the memory of its founder. It was the Honorable George Bancroft, who when charged, in 1845, with the care of the naval branch of the service, looked ahead into the future, and foreseeing the march of progress, and well appreciating the needs of *education*, conferred upon the Navy that ineffable boon, the full advantage of which we now reap. This revered sage still goes out and in among us, loaded with years and honors that a grateful people has bestowed, and occupying his time in still further adding to his enviable reputation in the present and rearing a literary monument which will preserve his memory to posterity; but no class of his countrymen have so much cause to respect and honor him, or have so strong a reason for gratitude to him as have the officers of the Navy.

The Chairman proposed the thanks of the meeting to Rear-Admiral Simpson for the valuable and interesting paper, and they were unanimously given. The meeting then adjourned.

APPENDIX.

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Selfridge, J. R.	Lieutenant
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Sterling, Y.	Commander
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Sutphen, E. W.	Naval Cadet
Talcott, C. G.	Asst. Engineer
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Taylor, H. C.	Commander
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Terry, S. W.	Commander
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Tilley, B. F.	Lieutenant
Tilton, McL.	Capt. U. S. M. C.
Totten, G. M.	Lieut.-Commander
Train, C. J.	Lieut.-Commander
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Turnbull, F.	Lieutenant
Turner, T. J.	Medical Director
Turner, W. H.	Lieutenant
Tyler, G. W.	Lieutenant
Underwood, E. B.	Lieutenant
Upshur, J. H.	Rear-Admiral

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Wood, W. M.	Lieutenant
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West, Thos. D., Esq. Cleveland, O.
Wheeler, F. M., Esq. New York
White, J. F., S. B. Torpedo Station
Williams, Albert U. S. Geological Survey, Washington, D. C.
Williams, W. B., Esq. Newark, N. J.
Wisser, J. P. 1st Lieut. U. S. A.
Willamov, G., Con. Gen. Russia, N. Y.
Wilson, A. E. Lieut. Chilian Navy
Woodall, W. E., Esq. Baltimore
Woodall, James, Shipbuilder, Baltimore, Md.
Zalinski, E. L. 1st Lieut. U. S. A.

CORRESPONDING SOCIETIES AND EXCHANGES.

United States.

American Academy of Arts and Sciences, Boston, Mass.
American Chemical Journal, Baltimore, Md.
American Geographical Society, New York City.
American Institute of Mining Engineers, New York City.
American Iron and Steel Association, Philadelphia, Pa.
American Metrological Society, Columbia School of Mines, New York City.
American Philosophical Society, Philadelphia, Pa.
American Society of Civil Engineers, New York City.
American Society of Mechanical Engineers, New York City.
Connecticut Academy of Arts and Sciences, New Haven, Conn.
Franklin Institute, Philadelphia, Pa.
Geographical Society of the Pacific, San Francisco.
Military Service Institution of the U. S., Governor's Island, N, Y.
School of Mines Quarterly, New York City.
Technical Society of the Pacific Coast, San Francisco, Cal.

Foreign.

Association Parisienne des Propriétaires d'Appareils à Vapeur, Paris.
Canadian Institute, Toronto.
Giornale d'Artiglieria e Genio, Rome.
Hydrographisches Amt der Kaiserlichen Marine, Berlin.
Institute of Mining and Mechanical Engineers, Newcastle-on-Tyne.
Institution of Civil Engineers, London.
Institution of Mechanical Engineers, London.
Mittheilungen a. d. Gebiete d. Seewesens, Pola.
Norsk Tidsskrift for Sovæsen, Horten, Norway.
Reunion des Officers de Terre et de Mer, Paris.
Revue Maritime et Coloniale, Paris.
Rivista Marittima, Rome.
Royal Artillery Institution, Woolwich.
Royal United Service Institution, London.
Société des Ingénieurs Civils, Paris.

NECROLOGY.

Clark, Lewis, Commander U. S. Navy. Born May 1, 1844, in Plymouth, Conn. Appointed to U. S. Naval Academy from Connecticut, September 24, 1861. Advanced to 3d Class, February, 1862. Appointed an Acting Ensign, October 21, 1863, and ordered to the U. S. S. Richmond, West Gulf Blockading Squadron. Battle of Mobile Bay, August 5, 1864. Attack on Spanish Fort and capture of Mobile, April 1865. Burned by explosion of torpedo off Mobile Point. Promoted to Master, May 10, 1866; to Lieutenant, February 27, 1867; and to Lieutenant-Commander, March 12, 1868. U. S. S. Ticonderoga, 1865-68. Naval Academy, 1869–72. U. S. S. Portsmouth, North Pacific Station, 1873–75. Torpedo Station, 1876. Granted one year's leave, 1877. U. S. S. Richmond, 1878–81. Commissioned a Commander, March 29, 1881. At Navy Yard, League Island, 1883. Ordered to command U. S. S. Alliance, July 5, 1884. Died on board the U. S. S. Alliance, at Key West, Florida, June 7, 1885.

Gorringe, Henry Honychurch, late Lieutenant-Commander, U. S. N. Born in the Island of Barbadoes, West-Indies, August 11th, 1841. Son of an Episcopal clergyman who was nineteen years Rector of the windward part of the Island of Tobago. Resident of New York in his youth. Appointed an Acting Master's Mate in the Navy, June 22, 1862, for duty in the Mississippi Squadron. Served on the Tyler. March 31, 1863, promoted to Acting Ensign, and served on the Baron de Kalb. September 26, 1863, promoted to Acting Master, and ordered to command the Cricket. April 27, 1864, promoted to Acting Vol. Lieutenant for courage, zeal and ability displayed. January 16, 1865, detached from command of the Cricket and ordered to the North Atlantic Blockading Squadron. Commanded the Monticello. July 10, 1865, promoted to Acting Vol. Lieutenant-Commander. July 18, 1865, detached from command of the Monticello and

granted leave of absence. August 15, 1865, ordered to command the Boxer. November 6, 1865, detached and granted leave of absence. November 10, 1865, ordered to command the Waxsaw. January 4, 1866, detached and ordered to command the South Carolina, name changed to the Memphis. April 30, 1867, detached and placed on waiting orders. May 9, 1867, ordered to command the Guard. April 7, 1868, commissioned as Lieutenant in the regular service, to take rank from March 12, 1868. September 30, 1886, ordered to examination for promotion. October 15, 1868, detached from command of the Guard and ordered to Navy Yard, New York. December 8, 1868, detached and ordered to the Portsmouth, January 5, 1869. January 13, 1869, commissioned as Lieutenant-Commander to take rank from December 18, 1868. November 17, 1871, detached from the Portsmouth and placed on waiting orders. November 22, 1871, ordered to the Navy Yard, New York. January 4, 1872, detached and ordered to the Hydrographic Office 10th instant. November 18, 1873, detached and ordered to command the Pinta. May 6, 1874, detached from the Mayflower and ordered to the Hydrographic Office. August 31, 1874, detatched and granted one year's leave with permission to leave the United States. September 15, 1874, leave suspended and ordered to the Hydrographic Office. September 19, 1876, detached and ordered to command the Gettysburg. Detached May 28, and ordered to the Hydrographic Office, June 16, 1879. August 1, 1879, detached and granted six months' leave with permission to leave United States. January 20 1880, leave extended six months; July 23, 1880, leave extended six months; December 28, 1880, leave extended six months. During this leave of absence Mr. Gorringe interested New Yorkers in his project of bringing Cleopatra's Needle from Egypt to this country. With their financial aid he procured a suitable vessel, altered her for the special service of carrying the obelisk on a long voyage, and arrived safely with it in New York, July 20, 1880. This notable achievement in engineering was commended by the scientific men of America and of the world. A full account may be found in the work of Mr. Gorringe entitled *Egyptian Obelisks*, published 1882 by G. P. Putnam's Sons, New York. July 27, 1881, furlough granted six months; continued on furlough until his resignation was accepted February 21, 1883. After his resignation from the naval service Mr. Gorringe became the organizer and manager of the American Ship Building Company of Philadelphia.

During the winter of 1885 when going to the shipyard he jumped from a moving train, fell and injured his spine. He suffered many months from the accident and died in New York, July 7, 1885.

GRANT, ULYSSES S., General U. S. Army. Died, July 22, 1885, at Mount MacGregor, New York. General U. S. Grant was elected an honorary member of the Naval Institute, October 21, 1880. On October 23, 1880, General Grant accepted, and extended his thanks to the Institute.

KARNEY, THOMAS, late Professor U. S. Navy. Thomas Karney was born at Annapolis, Md., July 16, 1810. He was the son of Capt. Thomas Karney, a distinguished officer in the war of 1812, who was afterwards Auditor-General of the State of Maryland. Prof. Karney graduated at St. John's College in 1830; was admitted to the bar April, 1834, but never practised; was appointed Examiner-General of the State of Maryland, August, 1834, and held the office until 1850; was appointed Asst. Prof. of Ethics in the U. S. Naval Academy, October, 1851, and served in the Department of Ethics and the Department of Ethics and English Studies until September 20, 1870, when he was detailed to serve as Librarian, which position he filled with signal ability up to the time of his death, March 31, 1885, at Annapolis, Md.

MARSTON, JOHN, Rear-Admiral U. S. Navy. Born in Boston, 1796. Entered the Navy in 1813. Served on board the frigates President and Java; brig Prometheus; frigates Constellation, Constitution and Congress; frigate Brandywine, Commodore Chas. Morris, when she conveyed La Fayette to France. Served in the various squadrons on board frigate Brandywine, schooner Dolphin, sloop Vandalia, frigate United States, frigate Potomac and sloop Yorktown. Commanded sloop Cumberland at bombardment of Hatteras. Commanded frigate Roanoke at Hampton Roads when the Merrimac came down from Norfolk, Va., and attacked the fleet. Performed duty as Light House Inspector at Boston, and various duties at Portsmouth, N. H., and Philadelphia until retired. Promoted to Commodore July, 1862, and to Rear-Admiral in 1866. Died in Philadelphia, April 8, 1885, from old age and general weakness.

NYE, HAILE COLLINS T., Lieutenant U. S. Navy. Born, October 14, 1850, in Marietta, Ohio. Appointed to Naval Academy, July 28,

1866, and was graduated as Midshipman U. S. Navy, June 7, 1870. Served from September 1, 1870, until November 1, 1873, on board the U. S. S. California, Narragansett, Supply, Kansas and Richmond. May 19, 1874, was commissioned an Ensign U. S. Navy from July 13, 1872. Served in Coast Survey in 1874, '75 and '76. Commissioned Master U. S. Navy January 1, 1875. Ordered to U. S. S. Pensacola, October 23, 1876. Detached and ordered to Asiatic Station June 2, 1878, and served on board the U. S. S. Monocacy till April 5, 1881, when he was granted three months' leave, with permission to remain in Japan. From January, 1882, to December, 1883, served at Navy Yard, New York, and at torpedo instruction, Newport. Ordered to Shenandoah, December 18, 1883. Transferred to Monongahela October 17, 1884, and ordered to duty with Minister to Peru. January 27, 1885, ordered to return to the United States with the remains of the late Minister Phelps. Died at Lima, Peru, July 30, 1885.

Peck, Ransome Byron, Lieutenant U. S. Navy. Born November, 1843, at Oswego, N. Y. Appointed from Springfield, Mo., November 20, 1861, and was graduated in 1866. U. S. S. Guerriere, South Atlantic Station, 1867–8, and U. S. S. Kansas, same station, in 1869. Promoted to Ensign in April, 1868, to Master in March, 1869. Special duty at Jefferson Barracks, Mo., 1870. Commissioned Lieutenant, March 21, 1870. U. S. S. California, Pacific Station, 1871–2. U. S. S. Ticonderoga, North Atlantic Station, 1873–74. Naval Rendezvous, San Francisco, 1875–6. U. S. Flagship Pensacola, North Pacific Station, 1877–8. Detached August 14, 1879, and ordered to U. S. Hydrographic Office, October 25, 1879, and served there until April 29, 1882. During remainder of 1882 was at Torpedo Station, on board U. S. Gunnery Ship Minnesota, and as Executive Officer of Monitor Nantucket. December 16, 1882, ordered to Swatara. August 5, 1885, detached and granted sick leave for six months. Died November 6, 1885, while en route to Honolulu.

Remey, Edward Wallace, Lieutenant U. S. Navy. Born May, 1847, in Burlington, Iowa. Appointed to U. S. Naval Academy, September, 1862, and was graduated as Midshipman U. S. Navy, in June, 1867. Minnesota special cruise 1867–8. Promoted to Ensign in January, 1869. Served on board Onward. Promoted to Master, August, 1870. Served in U. S. Coast Survey. Promoted to Lieu-

tenant, January, 1874. Served on Ordnance and Torpedo duty, and at Hydrographic Office, in 1874. April, 1875, ordered to Tennessee, and served there until July, 1878. Ordered to Hydrographic Office October, 1878. September, 1879, took passage in the Constellation and joined the Trenton. Was detached October 31, 1881. Ordered to Tennessee, December, 1881, and was detached July, 1883, and ordered as Executive Officer of the training Ship Portsmouth. Left Norfolk on board an Old Dominion steamer, February 14, 1885, and arrived in New York, February 17, 1885. Not heard from since.

SCHOCK, JOHN LOOMIS, Assistant Naval Constructor, U. S. N. Born March 3, 1860, Schock's Mills, Penn. Appointed to U. S. Naval Academy, June 19, 1877, and was graduated June 10, 1881. Ordered to U. S. S. Quinnebaug, June 24, 1885, and transferred October 21, 1881, to the Royal Naval College, Greenwich, England. Appointed an Assistant Naval Constructor U. S. Navy, July 1, 1883. Remained at the College until his death, May 23, 1885.

SEMMES, ALEXANDER A., Commodore U. S. Navy. Born in the District of Columbia. Appointed a Midshipman in the Navy, October, 1841. Attached to frigate Columbus, Mediterranean Squadron, 1841–3. Skirmish with natives at Grand Bereby, Africa. Sloop Vincennes, East India Squadron, 1845–6. Naval School, 1847. Promoted to Passed Midshipman, August, 1847. Naval Observatory, Washington, 1849–50. Frigate Congress, Brazil Squadron, 1851–52. Coast Survey, 1853. Naval Observatory, Washington, 1854. Promoted to Master in 1855. Commissioned Lieutenant in September, 1855. Steamer Massachusetts, Pacific Squadron, 1855–7. In November, 1856, commanded a force of twenty-three sailors and marines in a successful attack upon an encampment of one hundred Russian-American Indians in Puget Sound. Powhatan, East India Squadron, 1859–60. Steamer Rhode Island, Atlantic Coast, 1861. Commanding steamer Wamsutta, South Atlantic Blockading Squadron, 1862–3. Engaged in a skirmish with the rebels at an island in Newport River, Georgia, April, 1862. Commanding gunboat Tahoma, East Gulf Blockading Squadron, 1863–4. Attacked the batteries of Tampa, Florida, April, 1863, and October, 1863, attacked the same batteries as a ruse while sending a party of sailors to capture some blockade-runners. September, 1863, while in command of light-draught steamer, made demonstration on Bayport, Florida, which

resulted in destruction of an English blockade-runner and the warehouse containing her cargo. Commanded ironclad Lehigh, 1864–5. Bombarding Fort Pringle, July 7–10, 1864. Picket duty in harbor of Charleston, S. C., during fall and winter 1864–5. February, 1865, commanded Lehigh, and was senior officer of six vessels operating against the rebel defences on James Island. Fall of Charleston, 1865. Commanded Lehigh in midnight bombardment of the Howlett House Batteries on James River. Fall of Richmond. Ordnance duty, Philadelphia, 1866–68. Commissioned as Commander, July, 1866. Commanded sloop Portsmouth, South Atlantic Station, 1869–71. Pensacola Navy Yard, 1872–74. Commissioned as Captain, August, 1873. Commanded Alaska, European Station, 1875–76. April 5, 1877, granted one year's leave, with permission to leave the United States, and continued on leave until October 15, 1880. September 10, 1880, ordered to Navy Yard, Washington, D. C., as Captain of the Yard. Detached April 13; 1882, and placed on waiting orders. Commissioned as Commodore to take rank from March 10, 1882. Appointed President of the Board of Inspection and Survey, September 29, 1882, and was detached June 30, 1883, and ordered to the command of the Navy Yard at Washington, D. C. Died at Hamilton, Virginia, September 22, 1885.

NAVAL INSTITUTE PRIZE ESSAYS, 1879–1887.

1879.

Subject:—"NAVAL EDUCATION.—I. OFFICERS. II. MEN."

Judges of Award:—CHARLES W. ELLIOT, President of Harvard University; DANIEL AMMEN, Rear-Admiral, U. S. N.; WM. H. SHOCK, Engineer-in-chief, U. S. N.

Winner of the Prize:—Lieutenant-Commander ALLAN D. BROWN, U. S. N. *Motto of Essay:*—"Qui non proficit."

First Honorable Mention:—Lieutenant-Commander CASPAR F. GOODRICH, U. S. N. *Motto of Essay:*—"Esse quam videri."

Second Honorable Mention:—Commander ALFRED T. MAHAN, U. S. N. *Motto of Essay:*—"Essayons."

Number of Essays presented for competition, ten.

1880.

Subject:—"THE NAVAL POLICY OF THE UNITED STATES."

Judges of Award:—Hon. WM. M. EVARTS, Secretary of State; Hon. R. W. THOMPSON, Secretary of the Navy; Hon. J. R. MCPHERSON, U. S. Senator.

Winner of the Prize:—Lieutenant CHARLES BELKNAP, U. S. N. *Motto of Essay:*—"Sat cito, si sat bene."

Number of Essays presented for competition, eight.

1881.

Subject:—"THE TYPE OF (I) ARMORED VESSEL, (II) CRUISER, BEST SUITED TO THE PRESENT NEEDS OF THE UNITED STATES."

Judges of Award:—Commodore W. N. JEFFERS, U. S. N.; Chief Engineer J. W. KING, U. S. N.; Chief Constructor JOHN LENTHALL, U. S. N.

Winner of the Prize by decision of two of the Judges:—Lieutenant EDWARD W. VERY, U. S. N. *Motto of Essay:*—"Aut Cæsar, aut nullas."

Recommended for the Prize by one of the Judges:—Lieutenant SEATON SCHROEDER, U. S. N. *Motto of Essay:*—"In via virtute via nulla."

Number of Essays presented for competition, four.

1882.

Subject:—"OUR MERCHANT MARINE; THE CAUSES OF ITS DECLINE AND THE MEANS TO BE TAKEN FOR ITS REVIVAL."

Judges of Award:—Hon. HAMILTON FISH, Ex-Secretary of State; JOHN D. JONES, President Atlantic Mutual Insurance Company, New York; A. A. LOWE, Ex-President New York Chamber of Commerce.

Winner of the Prize:—Lieutenant JAMES D. J. KELLEY, U. S. N. *Motto of Essay:*—"Nil clarius aquis."

First Honorable Mention:—Master CARLOS G. CALKINS, U. S. N. *Motto of Essay:*—"Mais il faut cultiver notre jardin."

Second Honorable Mention:—Lieutenant-Commander F. E. CHADWICK, U. S. N. *Motto of Essay:*—"Spero meliora."

Third Honorable Mention:—Lieutenant RICHARD WAINWRIGHT, U. S. N. *Motto of Essay:*—"Causa latet: vis est notissima."

Essay printed by request of John D. Jones, Esq.—Ensign W. G. DAVID, U. S. N. *Motto of Essay:*—"Tempori parendum."

Number of Essays presented for competition, eleven.

1883.

Subject:—"HOW MAY THE SPHERE OF USEFULNESS OF NAVAL OFFICERS BE EXTENDED IN TIME OF PEACE WITH ADVANTAGE TO THE COUNTRY AND THE NAVAL SERVICE."

Judges of Award:—Hon. ALEXANDER H. RICE; Judge JOSIAH G. ABBOTT; Rear-Admiral GEORGE H. PREBLE, U. S. N.

Winner of the Prize:—Lieutenant CARLOS G. CALKINS, U. S. N. *Motto of Essay:*—"Pour encourager les autres."

First Honorable Mention:—Commander N. H. FARQUHAR, U. S. N. *Motto of Essay:*—"Semper paratus."

Second Honorable Mention:—Captain A. P. COOKE, U. S. N. *Motto of Essay:*—"Cuilibet in arte suâ credendum est."

Number of Essays presented for competition, four.

1884.

Subject:—"THE BEST METHOD FOR THE RECONSTRUCTION AND INCREASE OF THE NAVY."

Judges of Award:—Rear-Admiral C. R. P. RODGERS, U. S. N.; D. C. GILMAN, LL. D., President of the Johns Hopkins University; Hon. J. R. HAWLEY, U. S. Senator.

Winner of the Prize:—Ensign W. I. CHAMBERS, U. S. N. *Motto of Essay:*—"Thou too, sail on, O Ship of State."

Number of Essays presented for competition, two.

1885.

Subject:—"INDUCEMENTS FOR RETAINING TRAINED SEAMEN IN THE NAVY AND THE BEST SYSTEM OF REWARDS FOR LONG AND FAITHFUL SERVICE."

Judges of Award:—Rear-Admiral THORNTON A. JENKINS, U. S. N.; Commander W. S. SCHLEY, U. S. N., Chief of Bureau of Equipment and Recruiting, Navy Department, Washington, D. C.; and Captain JOHN CODMAN, of New York City.

Winner of the Prize:—Commander NORMAN H. FARQUHAR, U. S. N. *Motto of Essay:*—"Ut prosim."

Number of Essays presented for competition, three.

1886.

Subject:—"WHAT CHANGES IN ORGANIZATION AND DRILL ARE NECESSARY TO SAIL AND FIGHT MOST EFFECTIVELY OUR WAR SHIPS OF THE LATEST TYPE?"

Judges of Award:—Rear-Admiral E. SIMPSON, U. S. N., President of Board of Inspection; Captain MONTGOMERY SICARD, U. S. N., Chief of Bureau of Ordnance; and Captain AUGUSTUS P. COOKE, U. S. N., Commanding U. S R. S. Vermont.

Number of Essays presented for competition, seven.

These essays are now in the hands of the Judges, and the award will soon be made.

1887.

Subject:—"THE NAVAL BRIGADE—ITS ORGANIZATION, EQUIPMENT AND TACTICS."

All essays on the above subject to be sent in sealed envelopes to the Secretary and Treasurer, on or before January 1st, 1887.

PROCEEDINGS

OF THE

UNITED STATES NAVAL INSTITUTE.

ANNAPOLIS, MD.

Organized October 9th, 1873, at the U. S. Naval Academy.

Issued Quarterly. Annual Subscription, $3.50.

Single Copy, $1.00, except No. 31, $2.00.

Annual Dues for Members and Associate Members, $3. Life Membership Fee, $30.

Contents Volumes I. to X. inclusive, to be found in Vol. XI. page xxxiii to page xlvi inclusive.

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CONTENTS VOLUME XI., 1885.

APPENDIX.

VOLUME XI., No. 1. WHOLE No. 32. 1885.

VOLUME XI., No. 2. WHOLE No. 33. 1885.

VOLUME XI, No. 3. Whole No. 34. 1885.

Marine International Law. Compiled from various sources. By Commander Henry Glass, U. S. N.

VOLUME XI., No. 4. Whole No. 35. 1885.

ANNUAL REPORT OF THE SECRETARY AND TREASURER.

To the President, Officers and Members of the Institute:

Gentlemen:—I have the honor to submit the following report of the financial transactions for the year 1885, as deduced from the accounts of the three gentlemen who have held office during that year.

The cash statement is as follows:

RECEIPTS.

Balance on hand January 1, 1885, per report,		$ 427 79
From dues,		1961 53
From back numbers, returned and credited to dues,		4 00
From life-membership fees (11),		330 00
From subscriptions,		613 90
From sales of publications,		772 14
From extra binding,		38 75
From interest on bonds,		69 50
From premium on exchange,		15
		$4217 76

EXPENDITURES.

For postage, freight, telegraphing and incidental expenses at headquarters,	$ 274 64	
For messenger at headquarters,	295 83	
For stationery at headquarters,	51 86	
For expenses of Branches,	35 47	
For printing publications, &c.,	2812 56	
For copyright fees,	4 00	
For advertising,	20 00	
For purchase of back numbers,	8 75	
For Prize Essay for 1885,	100 00	
For engraving medal,	1 00	
		3604 11
Balance on hand January 1, 1886,		$ 613 65

Of this balance the sum of $206.12 belongs to the Reserve Fund to be invested as soon as practicable.

Bills outstanding—Printer's bill, No. 35, not yet rendered, probably amounts to $600.00.

Bills receivable—	Outstanding dues for 1884 and 1885,	$700 00
	Publications sold late in December, 1885,	200 00
	Total, ...	$900 00

The Reserve Fund.

This fund consists of the life membership fees and of certain surplus that has from time to time accumulated. During the year 1885 one United States 4 per cent. bond was purchased at $123.88, and there now remains the sum of $206.12 to be invested and credited to the Reserve Fund, which is to be held in perpetuity to guarantee the future interests of the Institute and of the life members in particular. The following bonds are now deposited in the vault of the Farmers' National Bank of Annapolis for safe-keeping, viz.:

Eight (8) United States 4 per cent. of face value $50 each = $400; five (5) United States 4 per cent. of face value $100 each = $500; total face value $900. Market value $1108.10; New York quotation January 1, 1886, $1.23⅛; interest payable quarterly from January 1; bonds run till 1907.

Two (2) District of Columbia 3.65 per cent. bonds of face value $500 each = $1000. Market value $1170; Washington quotation January 1, 1886, $1.17; bonds run till 1924; interest payable semi-annually, February and August.

Total face value of bonds, $1900; total market value, $2278.10.

Membership.

The total membership of the Institute now stands as follows:

Regular members, ...	580
Associate members, ...	121
Life members	60
Honorary members	8
Total membership January 1, 1886, . .	769
Total membership January 1, 1885, . .	763
Net increase, ...	6

During the year 1885.

	Regular Members.	Associate Members.	Life Members.	Honorary Members.
Died,	7	0	1	1
Dropped,	14	0	0	0
Resigned,	23	5	0	0
Transferred to life members,	5	0	...	...
Joined,	28	19	7	...

PUBLICATIONS.

The Institute has on hand back publications as follows;

	Copies Plain.	Copies Bound.		Copies Plain.	Copies Bound.
No. 1	199	...	No. 19	126	...
" 2	253	...	" 20	135	...
" 3	80	...	" 21	218	...
" 4	170	...	" 22	297	...
" 5	138	...	" 23	210	...
" 6	22	...	" 24	218	...
" 7	28	...	" 25	110	48
" 8	52	...	" 26	234	74
" 9	58	...	" 27	306	27
" 10	15	...	" 28	none.	6
" 11	233	...	" 29	318	26
" 12	52	...	" 30	262	6
" 13	12	...	" 31	150	58
" 14	10	...	" 32	none.	190
" 15	none.	...	" 33	32	146
" 16	238	...	" 34	109	102
" 17	none.	...	" 35	190	72
" 18	67	...			

The archive set, complete in twelve volumes, bound in full turkey, and nine copies of Vol. X., in two parts, bound in half-turkey.

In conclusion, I beg to state that the business affairs have increased so much in detail and importance that the best interests of the Institute demand the services of an individual who can devote his entire time to the work, and I respectfully suggest that an officer be specially detailed for this position.

JNO. W. DANENHOWER, LIEUT. U. S. N.,
Secretary and Treasurer.

SPECIAL NOTICE.

NAVAL INSTITUTE PRIZE ESSAY, 1887.

A Prize of one hundred dollars and a gold medal is offered by the Naval Institute for the best Essay presented, subject to the following rules:

1. Competition for the Prize is open to all members, Regular, Life, Honorary and Associate, and to all persons entitled to become members, provided such membership be completed before the submission of the Essay. Members whose dues are two years in arrears are not eligible to compete for the Prize until their dues are paid.

2. Each competitor to send his essay in a sealed envelope to the Secretary and Treasurer on or before January 1, 1887. The name of the writer shall not be given in this envelope, but instead thereof a motto. Accompanying the essay a separate sealed envelope will be sent to the Secretary and Treasurer, with the motto on the outside and writer's name and motto inside. This envelope is not to be opened until after the decision of the Judges.

3. The Judges to be three gentlemen of eminent professional attainments (to be selected by the Board of Control), who will be requested to designate the essay, if any, worthy of the Prize, and, also, those deserving honorable mention, in the order of their merit.

4. The successful essay to be published in the Proceedings of the Institute, and the essays of other competitors, receiving honorable mention, to be published also, at the discretion of the Board of Control; and no change shall be made in the text of any competitive essay, published in the Proceedings of the Institute, after it leaves the hands of the Judges.

5. Any essay not having received honorable mention, to be published only with the consent of the author.

6. The subject for the Prize Essay is, *The Naval Brigade: Its Organization, Equipment and Tactics.*

7. The successful competitor will be made a Life Member of the Institute.

8. In the event of the Prize being awarded to the winner of a previous year, a gold clasp, suitably engraved, will be given in lieu of a gold medal.

By direction of Board of Control.

JNO. W. DANENHOWER,
Lieutenant, Secretary and Treasurer.

ANNAPOLIS, MD., *January* 1, 1886.

Vol. XII., No. 2. 1886. Whole No. 37.

PROCEEDINGS

OF THE

UNITED STATES

NAVAL INSTITUTE.

VOLUME XII.

PUBLISHED QUARTERLY BY THE INSTITUTE.
ANNAPOLIS, MD.

PRESS OF ISAAC FRIEDENWALD,
BALTIMORE, MD.

THE PROCEEDINGS

OF THE

UNITED STATES NAVAL INSTITUTE.

Vol. XII., No. 2. 1886. Whole No. 37.

PACIFIC BRANCH U. S. NAVAL INSTITUTE,

MARE ISLAND NAVY YARD,

JANUARY 7, 1886.

COMMODORE JNO. H. RUSSELL, U. S. N., in the Chair.

SOME SUGGESTIONS FOR MANNING OUR FUTURE NAVAL VESSELS.

By COMMANDER HENRY GLASS, U. S. N.

With the introduction into our Navy, in the near future, of modern steel vessels of the highest attainable speed, with reduced top hamper and small spread of canvas, armed with high-power breech-loading rifled guns and rapid-firing machine guns of the most approved patterns, and fitted with complicated torpedo apparatus, it is obvious that a radical change must soon be made in the character of the *personnel* of our vessels of war, and in the methods of instruction and drill adopted, if we are to secure the objects for which are incurred the large expenditures necessary to create and maintain a modern naval force; that is, ships ready under all circumstances for any service required on the ocean in defence of the national interests.

It may safely be assumed that the Naval Academy at Annapolis, as now organized and equipped for the instruction and primary training of the future officers of the naval service, will keep pace with all modern improvements in naval architecture and ordnance, including in the latter branch the fabrication and management of torpedoes for

defensive as well as offensive purposes, and that it will continue in the future, as in the past, to send into the service young officers fully competent, with the experience gained in a few years afloat, to instruct and control the men placed under their command, and to handle to the best advantage the ships and guns provided by the Government. I propose, then, to offer for diccussion on this occasion some suggestions of what I consider necessary to give the highest efficiency to the enlisted men of the Navy, as being a subject of the most vital importance just now to the service.

In my opinion, certain important changes are required in the methods of enlistment and rating and pay of the men who are to serve in our vessels of war now nearing completion, or soon to be in course of construction, in order to secure a more efficient class of men than seems possible under the present system of enlistments for general service, or entry into the service through the apprentice-training ships, however admirable the latter means of recruiting for the Navy may have been under former conditions.

The complement of men assigned to our vessels of war has always depended primarily on the number of guns carried, with an additional force, in later times, to manage the engines and their dependencies in steamers. The class of guns, now become obsolete, that formerly composed the batteries of our ships required in action a number of men always in excess of the number needed to handle a vessel not in action, even in the days when sails were the only motive power at sea. If, then, as seems to be demonstrated in practice, the heavy guns at present used at sea can be handled with fewer men than formerly, there need be no hesitation in decreasing the complements of our vessels, provided we can secure greater efficiency among the men. Steamers of all classes will have even less sail power in future than is now considered necessary in our service, and the Admiral of the Navy, long an advocate of full sail power for vessels of war, has lately proposed building as a type-vessel an armed cruiser with absolutely no sail power. This is an extreme view not likely to be adopted; for, while ships cruise at sea, they will always have sufficient sail power to at least be kept under control in case of accident to the machinery or while lying to in a gale of wind. With the introduction of the modern guns, served, trained, and fired by mechanical appliances, the number of men required on board ships hereafter will certainly be largely decreased, but a much higher class of men will be found necessary to care for, handle, and, in case of

need, repair the complicated mechanism of the battery, than are now enlisted in the service.

At the same time that we shall, with smaller crews, avoid the overcrowding of men on the berth-deck, seen on so many of our vessels of to-day, there will be secured greater comfort for the men, better attention to hygienic conditions, and consequent increased efficiency of the crew of a ship as a whole. A better distribution of the berthing space can be secured, with increased stowage capacity for ordnance stores, coal and provisions, thus enabling our ships to keep the sea for longer periods cruising or on blockading duty, as the case may be. With the smaller number of men on board will be found also a decreased list of casualties in action.

But while, as said before, the modern guns will require fewer men to handle them, those men must be of highly trained mechanical ability, and to secure them for the service, higher rates of pay must be provided, with other advantages not now enjoyed by the enlisted man. The seaman of the future ships must be more than a smart topman: he must also be an artilleryman and a mechanic. It is not intended by this to assert that the highest type of seamanship is not an absolute necessity in the Navy. That will always be of the first importance, and the ship with the quickest, readiest men will, other things being equal, be found the most efficient vessel of war; but it is contended that men of the intelligence and skill required to work the modern gun, with all its complicated machinery, can easily acquire, and in a short time, all the essential knowledge of gear and sails required to perform the ordinary duties of a seaman on deck, or even aloft, in a gale of wind or while the ship is temporarily under canvas alone.

The seamanship of the future will in some respects differ as greatly from that of the past as do the vessels themselves from the old sailing ships. Sending up and down topgallant and royal yards, reefing topsails for exercise, and evolutions of a kindred nature, will no longer be practised, as they will no longer furnish the test of the readiness and efficiency of a ship's company; but handling the ships themselves under varying conditions of speed and weather, and performing the tactical movements of a squadron, will serve as a standard of comparison for ships and crews; and all this will require a sound judgment of the capacity of vessels of different types and a quickness to perceive and use accidental advantages that the present training of the service does not give.

Officers and men alike must learn, however reluctantly in some cases, that the naval service of the future will have little of romance, but that it will be a cool, ready, business-like application of the means furnished by modern science and research to the destruction of an enemy's vessels of war at the least possible cost to the country, with few, if any, opportunities for the display of personal prowess in boarding parties or cutting-out expeditions. The future policy of our Government undoubtedly will be to maintain a well-organized nucleus of a naval force of the highest character, rather than to keep afloat at all times an expensive establishment such as those possessed by some European powers; the ships of different types, to meet the varying conditions of service, especially in our own waters, all of the highest attainable efficiency, with highly trained officers, and the fewest number of men to each ship that may be found necessary in ordinary cruising. Every ship in commission will become to a great degree a training school from which can be drafted as needed a few men to fill essential positions among the crews of additional vessels put in commission in case of threatened hostilities.

It may be objected that the reduction in the crews of our ships suggested will render impossible hereafter landing parties to be employed in shore operations. To this the answer, in my opinion, should be that the men and officers of a vessel of war should never be sent on any service beyond the reach of her broadside guns; that the highest state of efficiency of which a man-of-war is capable, and the one in which she best fulfills the object of her existence, is when her guns are ready for action at any moment, manned by their proper crews; and, lastly, that the men who are to handle our guns in future will be too valuable material to be lightly risked to accomplish the small results that have usually followed sending parties of seamen away from their ships. That part of hostile operations had much better be left to land forces, to be taken rapidly from point to point as necessary by a well-organized transport service, for which the Navy could be called upon to furnish the few sea officers needed in time of actual war.

To obtain the class of men required in the service, rates of pay must be established such as skilled mechanics can command on shore, with the additional advantages of continuous pay while not on duty afloat, and reasonable retiring pensions for age or disability incurred in the line of duty, as compensations for the hardships and exposure of a life at sea always to be reckoned upon under the most favorable

conditions. Instead of asking Congress to increase the number of men now allowed in the Navy, with consequent larger appropriations for their pay, which is certainly most inadvisable until we have a much larger number of vessels in commission than at present, I would reduce the number of men in the service to its actual needs, keeping a proper reserve for ships fitting out, and apply the amount of money thus saved to increasing the pay of every rated man retained in the service. In this way, without additional cost to the country, can be obtained the object proposed, and a class of men secured and retained in the Navy in every way competent to perform all the duties to be required of them in the future. The enlisted men will be found more trustworthy in all respects, and they will possess an *esprit de corps* not possible under the present system.

While I hold that the training ships now in commission are not meeting the requirements of the future, and that from the nature of things they cannot do so, I am far from advocating an abandonment of the system. But I would urge that essential modifications be made in the course of instruction and drills pursued that are not possible while the old sailing sloops of war, with their antiquated armaments, are retained as school ships for the Navy. The boys and young men enlisted for future service in the Navy, at considerable expense to the Government, should be instructed, from the very beginning of their service, in handling the guns and appliances that they may at any time be called upon to use in battle. I would at once substitute for the sailing sloops now composing the training squadron, modern steamers lightly rigged, armed with the modern guns of the service, and fitted with torpedo apparatus and all the appliances of a cruiser of the present day, such as machine guns, search lights, and electric firing apparatus for the battery.*

These vessels should be kept cruising on our own coast, and a portion of every year of instruction should be spent at the steel works and foundries where the guns for the Navy are being constructed, in order that all the details of the guns and their carriages should be thoroughly understood. A number of those trained for future service should every year be taken into the shops and be required to perform

* Since the above was written (Nov. 16), the reports of the Bureau Officers of the Navy Department have been given to the press, and the same suggestions practically are found in the reports of the Chiefs of the Bureaux of Equipment and Recruiting and Construction, and appropriations are asked for to carry them into effect.

a portion of the mechanical work, to familiarize them with the use of tools, and to fit them to care for the guns when in actual service, and to make slight repairs that may become necessary on board ship.

To sum up, then, the following propositions are submitted :

Reduce the number of men in the service to its actual needs when the new ships are in commission, retaining only those of the highest intelligence and skill.

Increase the pay and allowances of the number retained to such a scale as will secure for the service skilled mechanics who are also seamen.

Change the whole course of drills and instruction in the training ships, to bring the apprentice system into accord with the new condition of affairs in the Navy.

It is, I believe, beyond question that the present force of enlisted men in the Navy cannot be trusted to perform the duties specified as being required in the future, and should we be forced, from want of the proper class of men, to rely upon the *personnel* we now have for the safety of our future ships, and to maintain the honor of the flag in action against a thoroughly equipped. alert enemy, all thoughtful persons will look with grave apprehensions to the result of such a policy. It is only by the skill of the officers of the Navy, aided by a mere handful of the men we have, and possibly by fortunate chances, that disaster and disgrace would be averted.

The question of keeping faith with the large number of continuous-service men and apprentices we now have in the Navy may be raised; but an easy solution would be found in subjecting every man to a rigid examination as to his present fitness for duty under the new conditions of modern warfare, retaining under their certificates, with increased pay, those who pass successfully and discharging all others with reasonable retiring pensions. Granting that this would entail some temporary expense, an action lost through retaining inefficient men in the service would inflict far greater loss on the country than to pay service pensions for the next fifty years to every man so discharged.

It may seem premature to attempt now to decide upon the qualifications of the men who are to serve in ships yet unbuilt, and for which appropriations have not yet been made ; but it must be clearly understood that the present ships and guns of our navy are obsolete, and if we are to have a naval force at all commensurate with the interests to be protected—and no one who has studied the

course of public opinion will question this—new ships must be at once commenced and rapidly pushed to completion.

In addition to the sums already appropriated for rebuilding the Navy, the Navy Department is now asking for a much larger amount, to commence building the new ships that will be needed within a very few years to replace all those now in commission, if the flag is to be carried at sea by an American vessel of war. The ships now in commission have nearly all been kept afloat simply by a system of temporary repairs that, from the very nature of things, will soon become impossible. Enough is known to-day of the future of naval construction in certain lines, as shown by foreign precedent and the conclusions of the Board lately organized, to decide upon the character of our new vessels, and of the class of guns that will be carried, as indicated in the plans of our Ordnance Bureau, to decide approximately upon the character and necessary strength of the crews that must be provided.

Under the most favorable conditions, years are occupied in building and arming a modern vessel of war; but how much longer time will be required to train the brain, the eye, and the hand of the man who is to manage the complicated machinery with which modern invention has replaced the armaments of a quarter of a century ago! No time, then, should be lost by the officers of the service in deciding upon what is necessary, and in formulating plans that will meet the needs of the present and the future. We must all soon be prepared to assume the responsibilities of a new condition of affairs in the naval service, and must expect to be held to a strict accountability by the country for the use we make of the means provided by the Government for carrying on the operations of the national defence at sea.

DISCUSSION.

Lieutenant DANIEL DELEHANTY.—*Mr. Chairman and Gentlemen*:—With regard to the problem of selecting and training the best material for the continuous-service men of the future, I think they should all be given the same facilities for obtaining the knowledge required for the new conditions in the Navy, and to this end I would like to see each ship we now have in commission supplied with at least one of the modern high-power guns, and have every man that is likely to be retained permanently in the service thoroughly instructed in

all the details of duty connected with them. Every ship in commission should be, as soon as possible, fitted with all the modern appliances for naval warfare, so that not only the men, but the officers as well, might become thoroughly familiar with them, and then their transfer from one of our obsolete hulks to a modern man-of-war would not be the bewildering change it is sure to prove under existing circumstances.

I cannot agree with the idea advanced that the seaman of the future must be a mechanic. Both seamen and mechanics will be necessary in their proper places, and the number of seamen might be decreased and the number of mechanics among the crew fixed at the number found necessary in actual service.

I fail also to see how the seamanship of the future will differ from the past except in range of duties. Spar drills will become obsolete, and reefing and furling less frequent, but for marline-spike seamanship, manning and handling boats, steering, etc., the handy seaman will always be required on board our ships. No matter how much the form of the ships may change, the qualities that make up what we term seamanship will always be necessary. Admitting all that can be urged as to the great importance of the duties of the guns' crews in action, it must be remembered that a ship is the means of carrying guns into action, and that this service will, as much as ever, require skillful seamanship. I doubt if the writer would be willing to command a vessel cruising at sea with a complement of men made up simply of mechanics, however skilled they might be in handling and repairing gun machinery.

On the score of economy, as well as availability, I consider the sailing ships we still have in the Navy the most suitable for training purposes, as it is only under canvas, and by taking the weather as it comes at sea, that the qualities of the seaman will be developed; but those vessels should be supplied with modern ordnance and all the appliances of a modern man-of-war, as is suggested for the proposed light-rigged steamers. Instead of spending a portion of every year at the steel works and gun foundries, to give all the men a knowledge of the mechanical work of guns and carriages, the necessary number of men, with adequate rates of pay, might be drawn annually from those establishments for duty on board ship. The pay and the responsible positions they would hold would be, I think, sufficient inducements to attract and retain in the service reliable and skilled mechanics.

Commander FREDERICK RODGERS.—*Mr. Chairman and Gentlemen:*—In my opinion, the necessity for a number of trained seamen on board a vessel of war, in fact, a number sufficient to form the bulk of the crew, will never be overcome. While the mechanical appliances are greatly increased, and consequently the number of mechanics, the same necessities for seamen remain, even for a ship without sails. We must have our expert leadsmen, helmsmen, and lookouts—the boats must be manned—and particularly on picket duty will seamen be required. In cases of sudden emergencies the same necessities present themselves, and, as a rule, I presume it will be found in the future, as heretofore, that the most active, intelligent seamen will be the best men at the guns. If it is

practicable to carry out a course of instruction that will introduce mechanics who are also sailors, so much the better.

There certainly can be no question in the mind of any officer who has given attention to the subject under discussion, that the principle upon which the paper read by Commander Glass is founded is sound; that is, that the education or instruction of the *personnel*, the men as well as the officers, must necessarily, in order that they shall be efficient, keep pace with the advance in the improvements of all the mechanical appliances for war. That we have made practically no advance in the latter for many years, may account for the fact that there has been scarcely any change made in the system of employing and instructing men in the Navy. As is suggested in the paper just read, much will be gained by anticipating the radical change now promised, and thus prepare the men, so far as is practicable, for the handling of the most modern implements of war. It is only in the matter of detail, or as to how this can be best effected, that there can be a difference of opinion. It seems to me, if the Navy is to be brought up to a proper standard, even with a reduction of the complements of vessels, that the present number of men allowed to the Navy will be small. Ten thousand men, not including apprentices, would be a small number, were the Navy increased to anything like a force adequate to our wants. No one will deny that the proper place to begin a radical change in the system of instruction is at the root of it; and in this case, of course, that should be with the apprentices. It is well known that in this country, where opportunities in civil life offer so many inducements to leave the service when still young, that, in order to retain a desirable number of men with military training, it is necessary to begin with a large number of novitiates. Look, for instance, at the small percentage of officers found in the service at the end of ten years from entering a class at West Point or Annapolis. The percentage of men remaining in the service who are derived from the apprentice system is still smaller—perhaps not ten per cent.—after supplying the proper means to train apprentices with modern appliances. The number of apprentices in training should be increased to at least twelve or fifteen hundred. The term of enlistment for general service, I think, perhaps should be five years instead of three.

In reference to the pay of men, I am not sure that it would be necessary to increase it materially. The pay of the men in our service seems to be sufficiently greater than that in other services. The pay, however, should unquestionably be equalized, and that of seamen gunners—which it seems to me would be the proper title—raised to agree more nearly with that of machinists, boilermakers and other mechanics. In the instruction of the *personnel*, classes of men rated respectively seamen gunners and armorers would seem to be the most important. At the present time an armorer gets $45.00 per month, and a machinist $70.00; the former, from the nature of things, should be worth as much as the latter. A second-class fireman receives at present six dollars more a month than a seaman, and we know how much more a man has to learn in order to become a seaman. The pay ought certainly at least to be equal. A first-class fireman gets one dollar more a month than a seaman gunner. In order properly to proportion them, if a seaman gunner is what he is intended

to be, he should at least have $40.00 or $45.00 a month. There are many good men now in the service with a C. S. C. who are capable of instruction; from my experience, the greater part of this class who are not too old might be retained. There is a large number of men advanced in years who will in any event soon pass out. With the present requirements of grading men for C. S. C., none but desirable men would remain, if the requirements were exacted.

Lieutenant-Commander R. M. CUTTS.—*Mr. Chairman and Gentlemen*:—I agree with Commander Glass in many of his points, but have a few suggestions to make. I do not believe that we shall, for many years, be able to class closely our new ships; therefore, rules for allowances for crews cannot be made generally, but a special one for each vessel will be necessary.

The men composing such a crew should be divided into two classes: skilled, such as gunners, torpedo men, and electricians, or perhaps call them by some other name; the other class to be composed of men of about the same type as the best of our present force.

On each vessel there should be enough of the first class to fully man the modern guns, take care of the torpedoes, and manage the electric lights and wires. These men should be selected from graduating apprentices sent first to the Ordnance Proving Ground at Annapolis, and then to the Torpedo School, or *vice versa*. The pay of these skilled men should be gradually raised as they progress in information, and after graduation they should be held subject to draft. Some of these men, of course, would develop special leanings towards the different subjects in which they are instructed, which would indicate the rates to which they should be appointed. I think this would form a permanent force capable of performing all the duties connected with the care and use of all the apparatus soon to be used on all men-of-war.

The second class should be, as I said before, of the type of our present force—the best type, of course.

I do not believe in landing parties, for, with the modern type of men-of-war, having so few guns and so few men to each gun, it would not be right to deplete the ship's company to the extent that would make the landing a success.

I think that the plan of putting enlisted men at work in steel manufacturing shops and others would not prove a success. I have seen it tried at the Washington Navy Yard with the seamen gunners, but they took so little interest that, in my opinion, the plan was a failure.

I also think that seamanship will not play a prominent part in the modern cruiser. Of course, the second class must be sea-going men, and, if possible, from the Training Squadron; but I think it is not necessary to have that high grade of seamanship-knowledge that was a necessity in former years.

Commander GLASS.—*Mr. Chairman and Gentlemen*:—I think there is some misapprehension of my position as to the need of seamanship in the future, or rather, the manner in which I would define seamanship. Seamanship is, I take it, intelligence and skill applied to the performance of duties on board a ship. Now, modern vessels of war are so different in general arrangement, rig, speed,

and armament, that the duty to be performed by the men of the crew will offer few points of comparison with that required on board the old sailing ships, whose rig, at least, we have perpetuated in the vessels we now have in commission, with the single exception of the Dolphin.

The old-time seaman, or quartermaster, who could keep a ship "full and by" to perfection, and make every possible inch to windward, would be quite lost if placed at the wheel of a steamer making, say, sixteen or eighteen knots, and changing course possibly every few moments. The same qualities, however, that distinguished the former men of our service are necessary, only in a much higher degree, and a different training is required. What I advocate is the suiting of the training to the actual duties to be performed, so that the man at the wheel, or serving a gun, will be in complete accord with the officer directing the movements of the ship or the fire of the battery; will understand exactly what is required at any moment, and be, to use such an expression, a thinking portion of the machinery. This I hold the seaman of to-day in our service not to be, and I doubt the probability of any but a few of the old man-of-war's men ever becoming available under the new conditions that have grown up.

It is true enough that no officer would willingly go to sea, or into an action, with a crew composed of men whose whole training had been in a machine shop, with no experience of sea life; but, in my opinion, the ship that went into action with a crew composed entirely of the best topmen that ever went aloft, but with no knowledge of the machinery now used about the battery of a vessel of war, might be in even a more unfortunate position. I think a happy mean can be found in giving to all the essential men of the crew a mechanical training, and at the same time instructing them in certain details of handling sails and gear, manning boats, etc., that, I agree with Lieutenant Delehanty, will always be necessary at sea.

The suggestion of still continuing in service for training purposes the old sloops of war, but of fitting them with all modern appliances, is, I think, impracticable. The ships themselves are so entirely different from the modern types of war vessels, that the duty required of the crew can never be similar, and it is only by training men in the duties to be actually performed that any proficiency can be obtained. The "bewildering change" to a modern vessel of war for service would still be too great. In this connection, it must not be understood that I advocate a simple visit to a gun foundry, of a few hours occasionally, by a class of boys or men under instruction. I would have them attend closely the entire construction of a gun and its carriage, and require of them an accurate knowledge of all their parts and of their importance—a knowledge to be obtained only by close application for weeks, or possibly longer, but a knowledge that would be invaluable to them in service. After this preliminary instruction, the men showing especial aptitude for mechanical employments should be selected for actual work in the shops, to fit them for duty as armorers, in place of the gunners' mates and quarter-gunners we now have in the service.

The allusion of Commander Rodgers to the small percentage of the present apprentices who remain permanently in the service is worthy of serious attention, and furnishes a strong argument in favor of my proposal—to increase the

pay of enlisted men and give them other advantages they do not have now. Our present system educates, at great expense to the Government, a class of young men who can in the great majority of cases secure better positions out of the service than they can hope for in the Navy after serving out their apprenticeship, and this even in the present state of our carrying trade. It would seem to be better and more economical administration to seek to retain in the service young men who, from their training and experience, are just becoming of value on board our ships.

The necessity of increasing the pay of the skilled men who will be required to handle our guns in future, is emphasized by the fact that we have been compelled gradually to increase the pay of machinists, boilermakers, and other men of the engineer force on board our vessels, in order to secure competent and trustworthy men for those positions.

The CHAIRMAN.—*Gentlemen*:—No one will fail to agree in the proposition that a much higher degree of intelligence is required in the men who are to fill important stations at the guns to be carried by our modern vessels, than was needed to handle the old smooth-bore guns of the service. The character of all the drills on board ship will be entirely different, and this is an important point suggested by the paper just read. They will be so different, indeed, that no time should be lost in commencing the instruction and training of the men who are to serve in the new ships, if they are to be made efficient in all respects. Upon the rapidity and accuracy of fire of the few guns now carried by vessels of war will depend the fate of engagements either between fleets or single ships, and these qualities can only be obtained by constant, careful practice.

In speaking of seamanship as a necessity of the service, I do not understand the writer to disparage this by any means, but to insist upon a type of seamanship in accordance with the duties to be performed at the present day. Seamanship is simply a thorough, ready knowledge of the duties to be performed on board a vessel at sea. The most important duties of men on board a vessel of war are at the guns, and a knowledge of their character and power and appliances must take precedence of all else. It must not be forgotten that actions will never again be fought under sail, except under circumstances so exceptional that no foresight can provide for them, and that the tactical evolutions, which in the past required for their success the smart, alert topman aloft, and on deck, have given place to a new system of combinations under steam that precludes the use of sails. In the actions of the past, when a sheet or brace was carried away by an enemy's shot, the active, quick seaman was required aloft to replace it at once, even a moment's delay being in some cases enough to cause defeat; but now machinery has taken the place of gear, and the future man-of-war's man must know how to handle it, and to replace or repair it at need.

As to drills with spars and sails being an important means of discipline among the crew, it is true that any drills systematically carried on tend to that result; but it may be questioned whether better results cannot be obtained by drills that will have a direct bearing on the duties to be performed in action, rather than in expending time in evolutions that will never find a place hereafter in combats at sea.

U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

THE NAVAL ASYLUM AND SERVICE PENSIONS FOR ENLISTED MEN.

By Lieutenant-Commander Chas. H. Stockton, U. S. N.

In presenting this paper upon the Naval Asylum, I wish to state that I was impelled to prepare it from the fact that so little is known of the Asylum and its workings. A very interesting historical sketch of its origin, and of the tract of land upon which it is situated, by Medical Director Edward Shippen, U. S. N., is the only printed matter upon the subject that I could find, outside of the usual references in the reports of the Chiefs of the Bureau of "Yards and Docks," and the still more meagre mention in the Acts of Congress.

By kind permission of Dr. Shippen, I have availed myself of some of the material contained in his pamphlet, and in addition I have drawn to a considerable extent from a manuscript sketch of the Asylum prepared by Commander Edward Hooker, U. S. N., a long time stationed at the Asylum, and whose services have been highly appreciated by the governors under whom he has served at that place. To both of these gentlemen I make my acknowledgments, and wish to express the hope that their labors will be generally appreciated.

In 1811 an act was passed by Congress establishing a Board of Commissioners of the Navy Pension Fund, who were also to be Commissioners of the Navy Hospitals. This Board was to consist of the Secretary of War, the Secretary of the Navy and the Secretary of the Treasury; and the act further authorized the above-named commissioners to acquire sites, buy and build hospitals for the naval service, and in addition to provide at one of the establishments a permanent asylum for disabled and decrepit navy officers, seamen and marines. In another section of the same act, the Secretary of the Navy is authorized and required to prepare the necessary rules and regulations for the government of this institution.

This act created the Naval Asylum now at Philadelphia, and, by the use of the word "Asylum," unfortunately gave it the name which it bears. Similar institutions of a later birth, for the regular and volunteer service of the Army, have had chosen for them the happier name of "Home," and it would be wise to adopt the same for the seamen's home of our service.

The legislation originating the Naval Asylum, as well as the Naval Hospital establishments, appears to have been directly traceable to a letter of the Honorable Paul Hamilton, then Secretary of the Navy, addressed to the House Committee on the Naval Establishment. This letter proposed many other matters for legislation, one being the establishment of a home or asylum for the widows and children of seamen killed in action, the sons of such seamen to be brought up for the naval service. Another proposition was for the instruction of the midshipmen of the service at one of these establishments—the first suggestion of a naval school that I know of in our naval history.

No immediate action appears to have been taken, after the passage of the act just mentioned, to found an asylum for the aged and disabled of the Navy; probably the war of 1812, so essentially naval in its character, fully occupied the administrative energy and resources of the Navy Department for the immediately succeeding period, and the subject passed away from the attention of the Department.

In 1826 a suburban estate near Philadelphia, known as the Plantation, and for many years a possession of the Pemberton family of that city, was purchased for hospital purposes. The price paid was $17,000, and the mansion of the estate was used for the hospital, abandoning the building formerly used for that purpose at the Navy Yard in Philadelphia.

About this time the question of the Asylum being revived, it was determined to erect, in accordance with the law, a large and permanent building for that purpose. Philadelphia was selected as the site for the Asylum; and it is stated that though it was not the intention at first to use the present site, or connect it with any hospital, still, after considerable discussion, the decision was finally made to use a portion of the Pemberton tract for that purpose.

I have not been able to find out the exact date of the commencement of the structure, but the appointment of Mr. William Strickland and Surgeon Thos. Harris, U. S. N., as commissioners for the erection, dates in 1827. Mr. Strickland was the architect, and Dr. Harris the surgeon in charge of the adjacent hospital, and afterwards chief of

the Bureau of "Medicine and Surgery" of the Navy Department. In 1832 the building was under roof. The grounds were then, as now, about twenty-three acres in extent, the original tract having, however, been modified in its boundary lines by sales and purchases, as well as by opening of streets and rectification of boundary lines. The jurisdiction over this property was ceded to the United States in the session of the Legislature of Pennsylvania held in 1832–33. Curiously enough, this cession was made in two sections of an act to abolish imprisonment for debt. The following year, April 15, 1834, an act was drawn up and passed making the cession in a more formal and deliberate manner, but including the proviso which reserved the right to serve all process, civil and criminal, of the Commonwealth of Pennsylvania; and furthermore directing that this cession should only continue in force so long as the territory should be used for the purposes of a United States Naval Asylum for sick and disabled seamen.

Up to 1832 the expense of construction was borne by the Hospital Fund of the Navy; but in that year a direct appropriation was made of $33,900 for completing the structure and furnishing one wing. In the same year, the Board of Commissioners of the Navy Pension, Privateer Pension, and Hospital Funds, was abolished, and the Secretary of the Navy was made sole commissioner or trustee for all of these funds, and so remains to the present day.

The Asylum building was occupied in the latter part of 1833, though appropriations of money still continued for the internal completion, continuation of work on the grounds, etc., until 1842. The entire cost of the building, excluding the finishing of the attics, was $195,600; about four-ninths of which came from the Treasury directly, the remainder from the Hospital Fund.

The building is an imposing structure of grayish-white marble, with a granite basement; it is 380 feet in length, and consists of a centre with a high, broad flight of stairs and large abutments and a marble colonnade and pediment. The wings of the building are symmetrical, and terminate in transverse buildings at each end. Verandas have been constructed in front of the wings, well covered, which, though of great convenience, are out of harmony with the classic style of the central structure and general design of the exterior. All of the ceilings of both basement and first floor are vaulted in solid masonry, and on the first floor is a fine domed apartment, used as a chapel and mustering room. The most faulty part of the structure is the base-

ment, which is somewhat low and damp, with insufficiently constructed sub-cellar and inadequate system of drainage. This is better now than when the building was first completed.

Each beneficiary is provided with a room, small in size and plainly furnished; this is often much improved in appearance by the individual occupant, in accordance with his tastes and circumstances. The privacy given by these small rooms, not much larger than staterooms on board ship, is highly prized by the beneficiaries, and the additional independence and dignity given are of great value in fostering the sense of honorable retirement. In this feature the Asylum differs from the "Sailors' Snug Harbor" and the various soldiers' homes, and in a measure it compensates for the greater privileges and advantages offered by the latter. Besides these rooms, there are reading and smoking rooms in the transverse buildings, and quarters for officers and employees.

The first beneficiary (the official designation of an inmate) was admitted as such in 1834, Lieutenant James B. Cooper, U. S. N., having been detailed as superintendent of the Asylum during the month of April of that year. Before the end of the year, five others were admitted, and from this time forth the Asylum was duly in operation under the law.

A part of the Asylum building was designated as a general-service hospital from its first occupancy, and the southern portion continued to be used for such purposes until 1868, when the new general-hospital building in the same grounds was occupied, and the Asylum building used solely for its original purpose. During the Civil War, the number of sick and wounded being so great, all available space was used for hospital purposes, the necessities of the times obliging the Secretary of the Navy to so order it.

Up to 1858, though direct appropriations were made for repairs, improvements and other items of expense, the cost of the maintenance of the beneficiaries was defrayed from the Hospital Fund, until the growth of the Asylum and consequent increase of cost made too great a tax upon that fund. The Asylum then began to take the position of a separate establishment, and very justly, in that year, provision for the support of the beneficiaries was made in the Naval Appropriation Act. Since then annual naval appropriation bills have contained items for the support of the beneficiaries, pay of employees, and for repairs, care and improvement of the grounds and buildings. In 1869 the money for most of these purposes was directed to be

paid from the income of the Navy Pension Fund, and in 1873 it was directed that all expenditures for the Asylum should come from that source as duly appropriated by law.

As the inmates increased in the Naval Asylum, the want of proper organization, internal conveniences, and means of enforcing discipline, led to many reports and complaints on the part of the superintendent, Lieutenant Cooper, and complaints were also made by others to the Department. Lieutenant Cooper stated to the Secretary of the Navy that, from want of proper subordinates, he had been forced to assume a variety of duties, from superintendent to Master-at-Arms and cell-keeper. The attention of the Secretary was finally attracted, and Secretary Paulding, deeming a change desirable, wrote to Commodore James Biddle, offering him the charge of the institution, with, it is presumed, enlarged powers and the title of governor. The command of the Asylum was accepted by Commodore Biddle, and the official title then given to the commanding officer remains to the present time. The Asylum, which had been under the general jurisdiction of the Navy Yard up to the accession of Commodore Biddle, was then separated and created an independent command.

In 1839 a naval school was established at the Asylum; the building then containing three different institutions, the Asylum, the Hospital, and the Naval School. The first class ordered to the Asylum consisted of eleven midshipmen, all of whom had been for some time in the service. The numbers in attendance increased, and, with this increase, additional facilities for instruction became necessary, and were partly provided, until the school outgrew its accommodations (which were never suitable at the best), and finally, in the summer of 1845, it was removed to Annapolis, Md., at which place, and at Newport, it developed into the present fine institution, with its more than national reputation.

The Asylum was placed under the charge of the Bureau of "Yards and Docks" in 1849, then having Rear Admiral Joseph Smith as its Chief, and under his supervision great administrative improvement was made. The Asylum has continued under the cognizance of that Bureau until the present day. In the Deficiency Appropriation Act, approved March 14, 1864, was an item giving $75,000 for the extension of the Naval Asylum, and the following year, in the regular appropriation bill, was a clause which provided the sum of $100,000 to enlarge "the accommodation for sick, wounded and *otherwise disabled*" at the Naval Asylum, authorized by Act of Congress, March, 1864.

By these appropriations, $175,000 in all, the Naval General Hospital within the Asylum grounds was erected; and thus, under the shelter of the enlargement of the Asylum, whether intentionally or not, the Hospital Fund and establishment of the Navy has received back the money spent for the Asylum building and purposes. In addition, the use of a large portion of the building for general hospital purposes and the proceeds of several sales of portions of the original tract have repaid the fund for the purchase of the grounds.

Since the removal of the Hospital establishment from the Asylum building, the available space for beneficiaries has been gradually taken up, the increase being steady but slow, until now it is necessary to quarter the men in the basement and attic, both unsuitable in the warm weather. Recently, when quarters originally designed for officers were vacated on the second floor by the detachment of an officer, the vacant apartments were subdivided into smaller rooms for the use of the beneficiaries, in answer to the demands for additional space.

On the 1st day of January, 1886, there were at the Asylum:

On the rolls, ...	207	Beneficiaries.
On leave of absence, . . .	20	"
Under suspension, ...	4	"
In the Hospital, ...	14	"

Remaining under the Asylum roof, 169 beneficiaries.

In addition to the above, there were at that time fifty-one (51) marines and civilian employees quartered in the building, making 220 living there, exclusive of the officers, their families and attendants.

It will be observed that fourteen were in the Hospital; this refers to the General Hospital previously mentioned, the total number of patients from all sources being nineteen. It can be seen that the Hospital is really more of a hospital for the Asylum than for the service at large, over seventy per centum being from the Asylum. A large proportion of these are naturally men sent there on account of extreme old age, helplessness, and for purposes of special diet, making the Hospital to a certain extent an infirmary. As a matter of fact, there is an apartment there for the very old and childish which is known as the Nursery.

The Asylum is now under the command of Commodore Bancroft Gherardi, U. S. N., who as governor, by a considerate course of administration, makes of the institution as comfortable a home as the inconveniences of position, crowded conditions and antiquated state of the building and its appliances will allow.

The dining-room being in the basement, the aged men who are quartered in the attic are obliged to ascend and descend three flights of stairs three times a day, and there are many elements of danger in this height and stairway in case of fire. In other respects, also, the building is not of suitable design for its purpose. The attics, though large, and improved from time to time, especially under the administration of Admiral Rhind, are too low and hot in the summer. The dining-room is not in the proper place, and the kitchen and laundry arrangements are old and inadequate.

The food supplied is excellent in quality and quantity, and if the table is lacking in any way, it is due to the defective cooking arrangements and to the limited number of cooks and waitresses allowed by law. A remedy for this and other defects has been set forth in the report of Commodore D. B. Harmony, to the Secretary of the Navy, as Chief of the Bureau of "Yards and Docks."

The allowance of clothing is ample in quantity, reasonable in cost, and good in quality. The question of some change is now being considered, to give a greater variety in the allowance without any increased cost.

No attempt is made to place the institution upon a strictly military or naval basis, but to provide a home for the disabled and decrepit, and to give the greatest latitude consistent with cleanliness, good order and administration. All are allowed leave to go and come, unless the privilege is forfeited by bad conduct. The reading-rooms and library are provided with a good collection of books, and the Bureau subscribes to daily and weekly journals and magazines for the benefit of the inmates. The chapel services are enlivened by music paid for by the Asylum.

A small number of men are rated and classed as petty officers and attendants, and do duty as such, receiving an allowance of pay for their services; the allowance for the other beneficiaries for pocket-money is one dollar per month. A small increase of this meagre allowance is and has been asked for by the various Chiefs of the Bureau. A more liberal allowance is needed in this and some other matters. As usual with all naval institutions and men, the comparison with similar institutions and privileges of the Army shows the better treatment of the latter branch of the service; and in the matter of pensions and money, the inmates of the soldiers' homes fare better, notwithstanding that the requirements for admission to the Asylum are far more rigid. The most prominent instance of this is the surrender

of the pensions of the pensioned inmates to the Hospital Fund of the Navy. This custom, for there is no law requiring it, originated when the Asylum was supported by the Hospital Fund; but this support has long since ceased, the original force of the custom alone continuing the practice. The assignment of the surrendered pensions to the pensioners direct is not advocated, as, with so many wants supplied, and with the habits of drunkenness formed in the service, the money in many cases will be quickly squandered; but as the Government stands in the place of guardian, the pensions could be assigned to the credit of the Asylum, to be expended, under the supervision of the Bureau, for the increase of pocket-money to a limited extent, and to the further provision of comforts to the aged and enfeebled, such as special diet, spectacles and artificial teeth, etc., for those needing them, and additional amusements, entertainments and music for all of the beneficiaries.

Many applicants for permits are stationed or residing at a long distance from Philadelphia, some as far as California, and these men, when granted admission, are often entirely without the means to take them to the Asylum; and as there are no funds available for that purpose, the permit is either refused, or the charity of others invoked. A small amount, if duly appropriated and carefully expended, would remedy this, and prevent the successful applicant from a dependence upon private charity for his travelling expenses to Philadelphia, or looking upon his permit as a hollow mockery.

The pensioner should also have the privilege, now existing and sanctioned by law in the soldiers' homes, of surrendering his pension to his *dependent* wife, child, or parent during his stay in the Asylum. To this, if carefully supervised, there seems to be no serious objection on the score of justice or expediency.

These suggestions of increased liberality of treatment may seem too generous to some; but when it is considered that these men became disabled and worn out in the service of the country, without means of acquiring a support for themselves in their old age, and further, that the money proposed to be additionally expended either comes from their own pensions, duly surrendered, or from the income of the Navy Pension Fund, from which they are supported, it seems not charity, but justice. The Navy Pension Fund, itself in greater part created by the exertions of the officers and men of the naval service, is sacredly set aside by law for the payment of pensions, and for the care and comfort of disabled officers, seamen and marines of the Navy.

I will mention here, in addition to the above, that there are a number of men who have served in the Navy alone, during the war, who are now inmates of the volunteer soldiers' homes. They should be, if proper objects of the care of the Government, at the Naval Asylum; and as it is the fewer privileges and the want of room at the Asylum which both lessen the attractions and limit the entries there, both of these defects should be remedied, and the soldiers' homes relieved of the unwelcomed care of our own beneficiaries.

Under Section 4811 of the Revised Statutes, the rules and regulations governing the Asylum are prescribed by the Secretary of the Navy. Under his direction, this was done at first by Commodore Biddle and afterwards by Admiral Smith in 1849 and 1851; afterwards the regulations were revised and incorporated in the Navy regulation books of 1870 and 1876, those given in the last-named book being the ones now in force, though much in need of further revision.

The present requirement for admission is twenty years of service, accompanied with a certificate from a naval surgeon that the applicant is unable to support himself by manual labor. In extraordinary cases, and by the written permission of the Secretary of the Navy, this rule of service can be waived, and a disabled man of less service admitted. Hence, a man having less than twenty years of service, no matter how badly disabled by wounds, disease or exposure in the line of duty, can only be admitted as an exceptional case. This is certainly neither just nor generous, and though the present space would not, at this moment, allow the practice of a more liberal requirement, still, simple justice should at once enlarge the present requirements for admission, as well as the available accommodations at the Asylum.

Various questions have arisen and suggestions been made in regard to the Asylum and its existence, which can be narrowed down to three propositions:

1. The advisability of the abolition of the Asylum.
2. The enlargement of the Asylum on its present site.
3. The removal to another site, with larger buildings, increased facilities and ampler surroundings.

Taking up, first, the proposition, urged by some, to abolish the Asylum and to follow the example set by the English government, which was to break up the Greenwich Hospital as an Asylum for pensioners, disperse the inmates, and substitute a pension for those able to provide homes for themselves, and to place the sick and very helpless in the various service hospitals and infirmaries. There seems to be no reason why we should follow this example.

The Naval Asylum was established for disabled and decrepit navy officers, seamen and marines; and the regulations for admission prescribe that the disability should be so great as to prevent the inmate from supporting himself. Here, then, is the actual need which the Asylum meets, and for which it should exist. By law, out-door relief is already provided by pensions given, in Sections 4756 and 4757 of the Revised Statutes, to those desiring them in lieu of the home in the Naval Asylum. If this should be supplemented by legislation giving the seamen of the Navy the same retired list and pay which has been already provided for the Army and Marine Corps after thirty years of service, the system of out-door relief for the veterans and disabled would be complete. The question of pensions to those who serve twenty years and leave the service in a good physical condition, is a question which pertains to the general question of naval reserve, defence, and inducements for the retention of trained men, and will not be discussed here.

As a humanitarian need, and as a matter of justice towards those who give up their life and health to the service, the Asylum should exist. There is no class of men who are so helpless on shore, even when in health and vigor, as seamen; and the restless, roving nature of their occupation makes them more peculiarly helpless in old age and disability. They have been so universally victims of the baser elements of mankind that prey upon them in our seaports, that governmental and philanthropic means have been provided for their protection and care while in the prime and vigor of their life and while in the most active pursuit of their calling. If "Rests" and "Homes" are needed then, how much more urgently are they needed in their later life, when their earlier habits are more indelibly fixed and the care more imperatively needed! Though this state of partial vagabondage is far from being an ideal one, still, all who have studied the question know that it is real.

Considering the question from an economical aspect, the following statements can be made:

In the fiscal year 1884–1885, the average cost of a beneficiary, charging all expenditures, such as subsistence, clothing, pocket-money, pay and subsistence of employees, allowances, care and repair of buildings and grounds, cemetery expenses, etc., but excluding pay of the naval officers stationed there, was $286.26. For subsistence, clothing, pay and tobacco alone, it was $164.78. This does not include the cost of the building and grounds or the interest of money

expended for both. It excepts the Asylum and its grounds as an established expenditure.

Section 4756 of the Revised Statutes provides that "there shall be paid out of the Naval Pension Fund to every person who from age or infirmity is disabled from sea-service, but who has served as an enlisted person in the Navy or Marine Corps for the period of twenty years, and not been discharged for misconduct, in lieu of being provided with a house at the Naval Asylum, Philadelphia, if he so elects, a sum equal to one-half pay of his rating at the time he was discharged," etc., etc.

With the present rates of pay, and without considering the question of increased pay by continuous service, the pension for out-door relief, under the above law and with the pay now prescribed, following the classification as shown in the Navy Register, would be:

For petty officers of the	1st	class, from	$210	to $420.
" " "	2d	" "	161	" 360.
" " "	3d	" "	162	" 240.
" seamen and others of all classes,		.	96	" 210.

After a service of twenty years, the most deserving men would be holding the rate and increased pay of petty officers, the less deserving would be seamen, etc., and the least efficient of all would be in the lower grades. Good and efficient service is thus rewarded in the present system of out-door relief or service pension, and the compensation in the majority of deserving cases is greater than the average cost of the support of a beneficiary, $286.26. As the number in the Asylum increases, the average cost of support naturally lessens, and there is no doubt in my mind that the inmates receive more material comforts, better care, and more generous allowances, at a less cost than would be possible were the same amount of money expended separately on each one. A proof of that is the comparatively large proportion of inmates who are pensioners and who surrender pensions to enter the Asylum. As a matter of justice, humanity and economy, then, I think the Asylum should continue.

Granting the continuance of the Asylum, with or without more liberal provisions for entrance, the question of enlargement is an urgent one. The Asylum is now about full, as stated before, and if those in the Hospital and on leave were to return to the Asylum, there would not be places for all of them in the building. The quarters in the basement and attics are unfit in certain seasons for their purpose,

and men have to climb up and down stairs who, from their physical condition, ought not to be compelled to do so.

There are several officers quartered in the Asylum building, as the governor's and surgeon's residences are the only ones outside the main building. Valuable space is necessarily taken in this way in the second and third floors and in the basement. The marines, the male and female employees and the servants of the officers, are also quartered in the building; the female employees being separated by a lattice door only from the beneficiaries, and all having to use the corridors and stairways in common.

In addition to the steady increase, those men who entered the Navy at the urgent call of the country, and who remained in the service, are now eligible to the Asylum, and require accommodation. They cannot be refused; nor is it intended by Congress, in its well-known liberality, that the soldiers and sailors of our late war should be excluded. Temporary means of enlargement have been suggested in various reports by the different chiefs of the Bureau—among others, the use of part of the adjacent General Hospital, but a limited portion of which is occupied for hospital purposes. These means will probably have to be availed of in the course of time; but they are but makeshifts, and serve to postpone the inevitable and systematic enlargement or removal. The present Asylum building is inconvenient in its arrangement, height, and general style of architecture, and not well adapted for its purpose, and hence an extension of that building would be but a partial remedy.

The truth is that the site at Philadelphia is unsuitable. Situated as it is in the midst of a large city, overlooking what once was a beautiful stream, but which is now not more than a canal; its water-front used for the reception and discharge of manure; surrounded by streets; its grounds to be invaded by a railroad, and the neighborhood none of the best, it is quite time the naval and seamen's retreat should be moved to a better place and near more suitable surroundings. Facing the Asylum, on the opposite bank of the river, is the Blockley Almshouse of the city of Philadelphia, and the juxtaposition of the two institutions has led to the derisive cry of "Government paupers" being addressed to honorably retired men of our service by some of the denizens of the neighborhood. Though the position of the Asylum affords various conveniences, and many of the beneficiaries have formed attachments and associations which would lead them to regret at first the change from Philadelphia, still, a comfortable home

near the sea, in a mild climate, within sight of the active movements of shipping, would soon reconcile them to the change, and would awaken a sentiment most healthy and desirable. If added to this were opportunities afforded for out-door amusements and occupations, such as boating, fishing, bathing and kindred recreations, the artificial and injurious attractions of a large city would speedily be counterbalanced.

In consideration of the above disadvantages of the present situation of the Asylum, the advantages of a seaside position in a mild climate, and the further urgent necessity for a proper and systematic enlargement of the buildings and facilities of the Asylum, involving almost a complete reconstruction, it would in every way be advisable to make a complete removal and construct needed buildings, carefully designed for their special purposes, fitted with the latest and most modern appliances, and with ample surrounding space and water-front. No place seems to meet more fully all the requirements for the new site of the Naval Asylum, as stated, than the vicinity of Hampton Roads and Newport News. Central in its position on our Atlantic coast, with an abundance of water-front, protected from sea and wind, having ample facilities for boating and fishing, with mild and equable climate, near the best markets in the country, in proximity to the cities of Norfolk, Richmond, Washington, and Baltimore, and in ready communication with all by boat and rail, I know of no other place so suitable in all its advantages. Farther north the severity of the climate is objectionable on account of the age and enfeebled condition of a majority of the beneficiaries. Farther south the possibility of malarial and other fevers would present disadvantages.

To an extent, Hampton Roads and Fortress Monroe are both naval and military rendezvous, and the movements of naval vessels and the sight of military life would be congenial to both the aged seamen and marines. The fact of the presence of the Branch Volunteer Soldiers' Home, while proving the availability of the site, would be unobjectionable, and its popularity as a home, both among our soldiers and sailors, shows that the change would end in being a most grateful and acceptable one to those immediately concerned.

The comparative cheapness of the land in that vicinity would allow the purchase of a large tract, portions of which could be used for farm purposes, furnishing milk, fruit and vegetables in abundance; and the sale of the present site, valuable for building purposes, ought to reimburse the Government for the expense incurred for the pur-

chase of ground, construction of the necessary buildings, and the expenses of removal. Care should be taken, though, that the old buildings should not be given up until the new are fully ready for occupancy.

In addition to the material advantages presented by a site at Hampton Roads, the historical associations, traditions and sentiment of that vicinity should not be ignored. In the war of the Revolution, in the war of 1812, and in our late Civil War, most prominent scenes in the historical drama were there acted. Yorktown, Craney Island, and the engagements of the Merrimac, ending in the duel of the iron-clads, are all associations of that vicinity, and many actors in these latter scenes could, while ending their days quietly in the Naval Home, fight over again those grand engagements of the Cumberland, the Merrimac and the Monitor, the world-wide glory of which is so evenly distributed between the contending forces of the North and South.

STATISTICS OF NAVAL ASYLUM, 1885.

Number of men on rolls January 1, 1885,		199
Admissions during year,		22
Re-admissions during year,		4
Total,		225
Died during year,	12	
Dropped,	3	
Dismissed,	3	
Decrease,		18
Remaining on rolls January 1, 1886,		207
Number of blue-jackets,		143
Number of marines		63
Late Lieutenant U. S. N.,		1
		207
Number having 20 years and more of service,		147
Under 20 years,		60
		207

Average age of inmates,	64.05	years.
Oldest inmate,	97	"
Youngest inmate,	40	"

Number of pensioners on rolls, ... 98
Pensions varying from $4 to $24 monthly.

Nativity of Beneficiaries.

United States,	103	West Indies,	2
Ireland,	59	Finland,	2
Germany,	14	Italy,	1
Scotland,	8	Belgium,	1
England,	6	Wales,	1
Sweden,	3	Norway,	1
Denmark,	3	Nova Scotia,	1
Canada,	2		

NAVAL INSTITUTE, ANNAPOLIS, MD.

THE CASE OF THE MIGNONETTE.

By Henry Winthrop Hardon, A. M., LL. B.,
Law Orator for 1885, Harvard University.

There was presented in December, 1884, for decision in an English Court of Appeal a case absolutely without precedent in the English law. It was a case of peculiar interest, for though an English court had never been called to pass upon it, the question was one which had been discussed by casuists since Cicero's time, and once by Grotius, the founder of international law, and once by a great English Chancellor, Lord Bacon, and always with the same result. The case involved the death penalty, and Lord Chief Justice Coleridge, reaching a new conclusion, sentenced the prisoners to be hanged. This decision suggests an inquiry into the theory of criminal punishment in the English and American law.

The facts in the case were briefly these:

The Mignonette, an English yacht of nineteen tons, foundered at sea in the South Atlantic, during a severe storm, on the 5th of July, 1884. She was then on a voyage out from Southampton, bound for Australia, in charge of a captain and crew of three. In view of the events which subsequently occurred, it is important to state that Dudley, the captain, was a man of exemplary character, and a sailor of great experience. Such was his reputation wherever he was known. The rest of the crew were two men, and a boy, named Parker, eighteen years old.

The captain and crew got safely to their boat when the yacht went down. They had had no time to secure any water, and their only provision was a mere handful of food the captain had saved. They were sixteen hundred miles from the Cape of Good Hope. The small stock of food was quickly exhausted, and then, until the event which took place on their twentieth day in the small boat, they had nothing more to eat.

On the sixteenth day the boy Parker had drunk sea water and become delirious; he lay afterwards helpless in the bottom of the boat. The three men had then become almost exhausted from their long privation, and were tortured with thirst. Their prospect of immediate rescue seemed slight. Their only hope for longer life lay in the sacrifice of one of their number. They must resort to this dreadful extremity or die. Dudley suggested that they should draw lots; but neither of the other men would agree to this, and the boy no longer comprehended what was said. Dudley then proposed that they should sacrifice the boy. From his condition it was clear that he had the shortest time to live. All must die unless they had speedy relief; their situation was desperate. It was finally agreed that, if there should be nothing in sight at sunrise and no rain came, the boy should be killed. At eight in the morning there was no sail to be seen and no rain. After a solemn and prayerful deliberation, Dudley bent over the boy and told him his time had come. He made no answer, and while the mate held the boy's feet, Dudley opened a vein in his neck with the blade of a penknife. There was no struggle, and all was over in fifteen seconds.

Five days later a German bark rescued the three men. They were then in a state of complete exhaustion; there was little flesh on their bones, and, whether sitting or lying down, they were continually in great pain.

On reaching the first English port, they went at once to a magistrate and made a statement about the wreck and subsequent occurrences, concealing nothing. They were immediately arrested, and shortly tried for murder. The jury found that all would have died before the rescue if the boy had not been killed. Their sympathies were warmly enlisted in the prisoners' behalf, and acting upon a suggestion of the judge, they adopted a very unusual course and brought in a special verdict, in which, after stating the facts, they declared that they were ignorant whether or not the prisoners were guilty of murder. A case was thus presented for the judges.

It is very clear that the act is embraced within the received definition of murder, and no previous case had established an exception upon such facts as these. The counsel for the defence pleaded that the homicide was justifiable on the ground of necessity, and thus, for the first time in the history of the English law, the validity of the defence of necessity in such a case as this was presented for judicial determination.

That necessity of a certain sort is a sufficient justification for an act which would otherwise be murder, was not denied. If a highwayman assault a traveler upon the road, and the latter, in seeking to escape and defend himself, kill his assailant, the homicide is excusable on the ground of necessity. If the boy Parker, immediately before the knife reached his neck, and in order to save his own life, had by any means succeeded in killing Dudley, the homicide would have been excusable on the ground of necessity. Manifestly, the necessity which would justify Parker in taking the life of his assailant is of a very different sort from the necessity which would justify Dudley in making the assault, and if one be recognized as a legally sufficient necessity and the other be not, it is a dangerous legal equivocation to describe both sorts by the same word. It merely adds confusion to the Mignonette case to describe it by the term which the defence applied to it. Necessity, as previously defined in the law of homicide, has a fixed legal character, and should not be tampered with.

In order to describe the case in terms which shall defy the possibility of misunderstanding and yet be descriptively true, it may be called a case of prudent self-preference. Obviously, it is very like the case of the man who steals bread to save himself from starving. The law is very clear that such a stealing is not to be excused on that ground. The Lord Chief Justice remarked this analogy, and, arguing from the extreme case to the less extreme, refused to admit a new exception to the received definition of murder, and sentenced the prisoners to death.

With all deference, I may say that the Court has not exhausted the subject of this case when it has remarked an analogy which exists between it and a case of larceny, even when they have added to this the argument of expediency. There is nothing so well calculated to mislead as an analogy, and the argument of expediency should be resorted to only as an *ultima ratio*. In the words of Lord Eldon, "It appears to me to be necessary, in deciding this case, to be well informed of the principle upon which the question turns."

What is the principle upon which this question turns? Clearly it turns upon the principle of the criminal jurisdiction in cases of murder—upon the theory of criminal punishment. What, then, is the theory of criminal punishment?

This is a difficult matter. The question has been answered in several different ways—in five, at least—but the main controversy lies between two of them. The first of these may be called the absolute

theory. It is Kant's and Hegel's. Kant tells us that there is an "eternal fitness" in punishment; so great is this, that if society were about to disband and had in its prison a criminal tried and condemned, it would be a fitting act to execute him before the social dissolution. Expressed in Hegel's mathematical form, the proposition is that wrong is the negation of right, and punishment being the negation of wrong, if the punishment equal the wrong and the two negations balance, then the positive right is again established. It is contended for this theory that it furnishes an absolute standard for punishment, and does not leave it to the subjective determination of the judge.

There is a sufficient answer to all this. The theory advanced is ethic rather than civic or politic; and it is ethic of that school known as ideal. Hegel so understood it himself, and he proposed to draw the civic up to the ethic and make them one. But, as the theory stands, it is in professed contradiction to the actual state of the law. Courts have neither the time nor the means to undertake inquiries into the questions which this theory properly raises. The law cannot attempt to punish every morally wrong act—not every selfish act, even though the consequence of the selfishness has been a loss of life to others.

Suppose the case of a sinking vessel. A passenger manages to get alone into a boat which would hold half a dozen and pushes off alone, regardless of the cries of five others, who are thus deprived of their only means of safety. The single passenger has exercised a prudent self-preference, but I think the law could not interfere. Suppose there are already six in the small boat, and before it pushes off from the sinking vessel a seventh jumps in and so swamps it, and four of the original six are lost. The latter is a case of frequent occurrence, but no one ever heard of a court's attempting to take jurisdiction over it. The ethical problem is more complex than in the former case, while the loss of life is more directly the consequence of the act in question; but both cases are equally beyond the limit of the law. Finally, put the case where the boat contained seven, but cannot long live in the sea with such a freight, and one voluntarily jumps overboard and goes down. We recognize such an act as one of distinct heroism. Ethically, it is measured as worthy of all praise—an act to be enforced by every sanction. Legally, it is not measured at all: it is beyond the measure of the law. This absolute theory of Hegel's, then, does not fit the criminal law as we find it: the criminal law is not yet an ethical system of an ideal type.

It remains to examine the second theory of criminal punishment. It has been characterized in contradistinction to the former as a relative theory. It is that the end of criminal punishment is the prevention of crime. The guilty man is punished that others may see and tremble. This explains the grosser forms of criminal punishment—stocks and whipping-posts and public executions and the exposure of criminals' heads at Temple Bar. The severity of the punishment aimed at frightening others from wrong.

This theory has been objected to as immoral, because it treats the criminal as a thing in punishing him not solely for his own act, but for the crimes that others may commit in the future; and because in so doing it disregards the fundamental principle of free communities that all men are entitled to equal rights and liberties. To the first objection it is to be answered that, whether it be immoral or not to treat a man as a thing, this is precisely what the State does in common practice. It needs only to cite the case of the conscript driven off to battle at the point of the bayonet, to make this sufficiently clear. With reference to the maxim of equality, it is to be observed that, however the equation may stand between two members of a community, it no longer serves when one is added to either side; and if the community be a mere aggregate, then, though it consist of only three persons, the rights of any two of them are greater than those of the third. If a community be not a mere aggregate, but a new entity, then, too, as between the individual and the community, the equation has no application, for the two are in their nature incomparable.

The end, then, of criminal punishment is to prevent the commission of further crime, and the State, by means of the criminal jurisdiction, will punish a murderer that other murders may not be committed. Such is the commonly accepted theory of criminal punishment.

There is, however, a limitation upon this theory. If the object of criminal punishment is the prevention of crime, obviously the evil which the punishment inflicts upon the wrongdoer must be greater than the advantage he derives from the wrongful act, or else the punishment will not prevent the commission of other similar wrongful acts. If the larceny of a hundred-dollar horse be punished by a fine of only five dollars, the punishment will not go far to dissuade the evil-minded in the community from the practice of horse-stealing.

If it shall be found that, in a certain class of cases, the evil which the State can inflict cannot overbalance the advantage which the wrongdoer gains from his act, then, plainly, the criminal law has

reached its limitation, and an attempt to punish in such a class of cases will be simply abortive. The State will not succeed in preventing the commission of similar wrongful acts. Does not the Mignonette case stand for just such a class? Plainly, a present death by starvation is a greater ill than the possibility of a future death; and the latter is the utmost that the law can threaten.

This consideration is not new. It was urged by Macaulay when he sat in the Commission to frame the Indian Penal Code. It seems to be of the very essence of the Criminal Law. It is a fundamental principle in the philosophy of conduct that right action is induced and maintained only by enforcing adequate sanctions. The law knows no sanction but physical punishment, or its modification, the money penalty, and in the nature of things it could enforce no other. Where this sanction is inadequate, the law must fail to achieve its end, and any attempt to assert jurisdiction must be futile. Thus we are quite prepared to find—and such is the fact—that the new German Code provides no penalty for such a case as that of the Mignonette.

The conclusion is inevitable that the case is beyond the limit of the law—beyond the point to which the law can reach. No punishment the law can threaten or inflict will prevent a recurrence of the act under similar circumstances. The courts, then, should not attempt to exercise jurisdiction.

To the mind of the English Court the act was murder—murder reduced to its lowest terms, perhaps; murder to satisfy no personal spite nor spirit of malice; murder in dire extremity, and committed by a good man in a manner as painless as possible, but still murder, well-reasoned, deliberate murder. In this view, there was no course for the Court but to sentence the prisoners to pay the penalty provided in such case, and that penalty was death.

It may be urged that it is the function of the pardoning power of a government to afford relief from unjust, or excessive punishment. This is unquestionably true, but has no application to the present case. The sentence was not unjust, if any court has jurisdiction to pronounce it; nor was it excessive, for the punishment was the only one provided for a deliberate killing. If it is once assumed that the Court has jurisdiction to deal with the case, then there is no ground for the exercise of the pardoning power; and if the accused are to be sentenced and then immediately pardoned, the State virtually says in the same instant: "These men are and are not guilty of murder." The inconsistency is glaring, but the course is that

which was actually adopted in the case, for, at the suggestion of the Lord Chief Justice and the Home Secretary, the death sentence was commuted by the Queen to imprisonment for six months.

We may agree with the final result, but the means by which it was reached are fairly open to criticism. The Mignonette case was not a case of murder. It was not a case of murder, because it could not be dealt with as all cases of murder can be dealt with. It is not properly within the criminal jurisdiction, and the English Court would have acted in a manner consistent with sound legal principle if, on becoming aware of the facts, it had refused to go further in the case.

U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

THE NAVY SIX-INCH B. L. R.

By Ensign T. S. Rodgers, U. S. N.

(By permission of the Bureau of Ordnance.)

In 1881 the Bureau of Ordnance of the United States Navy decided on the construction of steel breech-loading rifled high-power guns for the Navy, in such quantities as Congress should see fit to appropriate money for.*

In September, 1881, bids were requested from fifteen steel firms to furnish the steel for a 6-inch gun. The only two firms that responded were the Midvale Steel Works of Nicetown, Pa., and Park Brothers of Pittsburgh. For various reasons, the other firms all declined to compete for this contract. In April, 1882, an order was given to Park Brothers for a tube, jacket, and breech plug. After various experiments, and attempts and failures, they offered these pieces for inspection in May, 1884. The tube and jacket were rejected, but the plug was accepted, and the rest of the order cancelled. In June, 1882, a contract was made with the Midvale Steel Works for the material of two guns, and at various times since new contracts have been made with this firm, and they have supplied all the steel used in the manufacture of the 6-inch guns.

The first order was for one heavy and one light gun, the former to be wire-wound and the latter hooped. The price of the steel was fixed at so much per pound, the weight of the rough-forged, unbored tubes and jackets, and the rough-forged hoops, to be taken as the basis of payment. It was agreed that the company should take back the steel waste at so much per pound, and should furnish the Bureau test bars at a fixed price per bar.

* One 6-inch low-power gun, known as the "South Boston Gun," had previously been made.

Tests of Metal in Guns Nos. 1 and 18.

Part of Gun.	Tensile Strength.		Elastic Limit.		Elongation after Fracture.		Reduction of Area after Fracture.		
	No. 1.	No. 18.	No. 1.	No. 18.	No. 1.	No. 18.	No. 1.	No. 18.	
Tube.	74,768	84,530	29,833	42,149	28.52	23.87	39.41	46.05	
Jacket	75,000	88,300	34,065	44,200	27.58	22.80	42.23	38.50	
A	102,267	116,700	44,733	68,700	18.48	14.92	26.79	25.90	
A	88,465		39,810		25.53		37.41		
A	93,733	121,769	41,235	68,980	23.71	15.95	36.72	31.05	
A	86,436		41,030		29.40		45.60		
A	91,523	108,112	52,337	63,025		15.20		29.18	
A	94,607		49,553		18.67		28.35		
A	90,709	107,543	41,694	59,854	23.30	16.45	32.37	32.65	
A	109,881		44,117		12.32		12.31		
B	107,314	101,672	46,297	53,618	18.17	16.70	24.19	29.20	A″ in No. 1.
C	93,030	99,608	33,104	54,932	16.45	17.42	21.16	39.36	A′ "
D	93,956	103,297	49,569	53,287	25.51	16.42	37.78	29.56	B "
E	110,574	102,700	44,896	55,200	15.13	17.30	18.73	33.10	C_1 "
	102,880		44,727		18.90		26.49		C_2 "
F	88,555	119,738	29,254	62,631	22.36	18.05	32.59	35.26	D_1 "
G	101,879	103,171	42,755	61,148	17.20	17.77	20.90	36.61	D_2 "
Tr.	82,501	81,191	45,701	41,600	12.30	12.10	22.00	13.32	

The steel for No. 1 is annealed, and for No. 18 annealed and oil-tempered.

Starting in with but little experience in this kind of work, but with a determination to do good work for, and to build up a business with, the Government, the Midvale Company has from the first been successful, and has gradually improved its processes until it has now reached a point where it can turn out with comparative certainty steel for this calibre as good as can be got in any market of the world. A look at the appended table, giving the tests of metal for the No. 1 and No. 18 guns, the first and last of the finished guns, will show a very great improvement in three important particulars: (1) in elastic strength, (2) the ratio of the elastic strength to the tensile strength, and (3) the uniformity of all the characteristics, especially the elongation and reduction of area.

I shall now go through the process of manufacture of the guns as now practised, noting the changes that have been made since the first gun (the only one which has been thoroughly tested), and first explaining briefly the design of the gun.

The design for Mark I. was made in 1881, and that for Mark II. in 1884. A sketch of the latter is appended. From this it will be seen that a tube extends the whole length of the bore. A jacket fits over the breech end of the tube and holds the breech plug. The trans-

verse strain is borne by the tube, jacket and hoops combined; the jacket and hoops being given an initial tension by being shrunk on. The amount of shrinkage is based on the actual characteristics of the metal, and is calculated so that for a certain internal pressure each of the three parts shall work at its elastic limit. The strength wall at the various points, and the shrinkages of the several pieces, were worked out by Virgile's formulae, the former being traced on the sketch. The longitudinal strain is taken up by the jacket, aided by the locking and trunnion hoops, and by the friction between the jacket and the tube and hoops caused by the shrinkage. This last is of course very considerable, but the jacket is made more than strong enough to bear any longitudinal strain that could possibly be put upon it. The jacket and *B* hoop being put on from the rear up against shoulders, and the *C* and *D* hoops in the same way from the front, the tube, jacket and these hoops are locked securely together by the trunnion hoop, which is screwed on. By this method it is also assured that the gun may not shake loose through much firing, and be driven to the rear through the trunnion hoop. The bore is thirty calibres long, and its total capacity is 5604 cubic inches. The capacity of the chamber is 1414 cubic inches, making the number of expansion 3.96. The cone between the chamber and bore is made long, to prevent the erosion caused by the gas rushing against a shoulder made by a sudden change in diameter. The various dimensions of the breech plug are calculated by empirical formulae based on experience with this system of fermeture both here and abroad. The elevating band is shrunk on, and adds but little, and is not intended to contribute any, to the strength of the gun. The gun is rifled with 24 lands and 24 grooves, the former 0.300 inch and the latter 0.4847 inch wide at the rear end. The grooves are 0.05 inch deep, with the corners formed by arcs of circles of 0.02 inch radius. The sides of the lands are inclined slightly in from the centre, and when produced cross each other and are tangent to a circle at the centre 0.15 inch in diameter. The developed curve of the rifling is a semi-cubical parabola. The twist starts with one turn in 180 calibres, increasing uniformly for 134 inches, where it is one turn in 30 calibres, and from there on it is uniform at one turn in 30 calibres to the muzzle. The reverse edge of the grooves is given a twist slightly less than that of the driving edge, in order to decrease the width of the grooves by 0.05 inch from the breech to the muzzle end of the bore. This is done to allow for the wearing of the band,

ensuring a good hold on it throughout the bore, and preventing the gases from getting by the band and causing erosion.

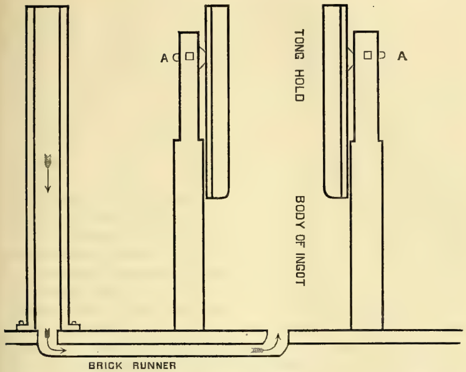
Mark I. was the same as Mark II. in all essential points, and differed from it only in certain details. The grooves in Mark I. were the same width throughout.

No. 1 gun was the only one made on the Mark I. design. All the others were made according to Mark II.

The gun is designed to fire a projectile weighing 100 lbs. with a charge of 50 lbs. of powder, this giving a density of loading of .99 in Mark I., and .98 in Mark II.

The tube is forged from an ingot of cast steel 30 inches square and about 55 inches long, with a tong hold 12 inches in diameter and 3 feet long, and weighing 15,000 pounds. In casting this ingot the charge is melted in the ordinary manner in a Siemens open-hearth furnace of 7 tons capacity. Just before the furnace is tapped the metal is stirred with hickory rods (Siemens' method). When the metal is about ready for casting, the fluid steel is tested several times by dipping out some of the steel with a spoon and pouring it into small moulds. The castings made in this manner are broken and the fractures examined with the eye, to determine the carbon and solidity of the metal. When all is ready the metal is tapped into a ladle and run from that into the mould, which is built of the shape shown in the sketch. In pouring the ingot the metal is run from the runner until it comes up into the bottom of the tong-hold mould. The ladle is then moved over the top of the mould and the rest is poured in at the top of the tong hold directly from the ladle. About five minutes is required to run the metal in from the bottom and five minutes more for pouring in at the top. After casting, several pots of crucible steel are poured into the tong-hold mould to feed the skrinkage, the last pot going in about an hour and a half after casting. During this time charcoal is thrown into the top of the mould to keep the top of the ingot fluid. The pins *A*, *A* are now taken out to free the tong-hold mould and allow the tong hold to shrink with the body of the ingot. The ingot is then allowed to cool in the air of the shop.

For forging, the ingot is placed in the furnace for the first heat, remaining about 24 hours. It is then put under the hammer and hammered gently all over to close the blowholes. It is then returned to the furnace and, in 18 hours more, heated with a blast to a bright forging heat, and reduced under the hammer to an octagon about 17



inches wide on each side, and then allowed to cool on the floor of the shop, when defects on the surface, brought out by hammering, are removed with a chisel. The forging is then reheated and hammered on a V-shaped anvil until it is gradually reduced to the required diameter. To forge the ingot to these dimensions requires about a dozen heats, and about twelve hours under the hammer. At each heat the ingot is hammered all over until it becomes too long for the furnace, when one end is heated and hammered at a time. When the forging is finished, the extra metal at the ends is cut off, and bars cut from this are tested. The tube is then annealed in a special annealing furnace at a heat depending on the physical characteristics exhibited by the last test. As the company has no facilities for rough-boring and turning, the tube is sent to the Washington Navy Yard for this purpose.

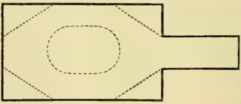
The jacket is made from an ingot similar in all respects to that for the tube, and the process of forging, annealing and testing is very much the same.

The hoops for the first few guns were made in the following manner: The ingot, about 13 inches square, and weighing about 1000 pounds,

was heated and first forged into a rough cylinder. A piece weighing about 400 pounds was cut off from the top, and the remainder was upset into a cheese-shaped cylinder, and a hole about 11 inches in diameter punched through it. After this it was reheated and placed on the horn of the anvil and hammered into shape, a tool interposed between the hammer and the hoop being used to finish it. The hoop was frequently shifted end for end on the horn, and was finally laid on top of the anvil and hammered on the ends. It was then annealed.

The hoops are now forged on a mandrel in the following manner: An ingot 15 inches square and 4 feet long, weighing about 3100 pounds, is heated and the upper third cut off, the lower two-thirds being cut into three or four pieces, according to the width of the required hoops. This bloom is reheated, hammered to an octagon shape on a flat die under the 9-ton hammer, upset and hammered to a disc 10 or 12 inches thick, then turned on the side again and rounded. The ingot is then punched, first with a conical punch, nearly through, then capsized and placed on an annular disc, and a second conical punch driven through. This is followed by a larger punch. The ingot is again capsized and the punch put through the other way. It is then hammered on the sides to smooth it, and then allowed to cool, in order to chip out any imperfections. The hoop is then from 10 to 12 inches thick, with a hole 9 or 10 inches in diameter. It is then hammered on a slightly tapered mandrel, on a V-shaped anvil, and then finally hammered in a die to the proper width. It is then oil-tempered, and test bars are submitted for inspection.

It was at first intended that the trunnion hoops should be of forged steel. With this view, two attempts were made to reduce a cast ingot



under the hammer to a slab like this sketch, and, by punching a hole in the centre, cutting off the corners, and delicate hammering, to bring it to the required shape. The first ingot had to be abandoned; the second was finished to shape, but the metal proved unsatisfactory. It was then decided to cast the trunnion hoops, and all of them were accordingly made in this way.

When the tube is received at the Washington Navy Yard, it is put in the lathe, great care being taken to have it exactly centred. It is then rough-bored to within ⅜ of an inch of the finished diameter. It

is then rough-turned to within the same margin. It is not rough-turned and bored closer to the finished diameter, on account of the slight warping which takes place in oil-tempering, thus necessitating recentring. The jacket is rough-turned and bored to within ¼ of an inch of the finished diameter in the same manner as the tube, except that a hollow boring-tool is used, which cuts out a solid core from the centre weighing about 900 pounds, which may be used to make a 3-inch B. L. howitzer.

The tube and jacket are then reshipped to the steel works, where they are oil-tempered. For oil-tempering, the tube or jacket is heated in a wood fire and then dipped a number of times in a bath of oil. The heat of tempering and the number of immersions are determined by the previous tests of the metal. This process is one of the most important steps in the manufacture, and on its success depend to a great extent the physical characteristics of the metal.

The metal is now tested by the Bureau, and if the tests are satisfactory the pieces are provisionally accepted and are returned to the shops. [6 of the 6-inch guns have been built at the South Boston Iron Works, 5 at the West Point Foundry, and the rest at the Washington Navy Yard.] No. 1 gun had none of its pieces oil-tempered, and was built up as the pieces came from the works.

The jacket is now put in the lathe and fine-bored as near as possible to the established diameter. It is then star-gauged. As it is much easier to cut to an exact diameter on the outside of an ingot than on the inside, the tube is turned down in wake of the jacket to the measured diameters of the corresponding parts of the jacket (+ the shrinkage). It is also fine-turned in wake of the chase hoops. The measurements on the inside of the jacket vary not more than .002 inch or .003 inch from the required diameters.

The tube and jacket are now removed to the shrinking pit. The tube is placed, muzzle down, in the centre of the pit and firmly supported there. A wooden box is built around the shoulder. The jacket, after being carefully cleaned and wiped out on the inside, is placed, breech end up, in a wrought-iron flask, and a wood fire built up all around it and lighted. This fire is kept burning until the operator, by inserting a gauge in the jacket, finds that it has expanded to the proper interior diameter to allow for the shrinkage and sufficient clearance to slip easily over the tube (about 0.01 inch or 0.02 inch all around). The flask is removed and the jacket lifted by a crane, transported directly over the tube, and lowered into its place. A

stream of cold water is then turned on the muzzle end of the jacket (in the wooden box), to make it cool there first and nip, drawing the rear part close against the rear shoulder.

When the jacket is cool, the gun is lifted from the pit and placed horizontally on skids. The chase hoops, bored out to the established diameter, are successively heated in the same manner as the jacket, and after being carefully wiped out are slipped over the tube and forced into place, while a stream of water is turned on the end of the hoop nearest the trunnions, in order to make it nip there first, and thus make a neat joint with the jacket or the hoop next to it.

When all the chase hoops are shrunk on, the gun is once more put in the lathe and the jacket turned to size, and the chase hoops and chase fine-turned. The *A* hoops are then shrunk on in the same manner as the chase hoops, and the gun is again put in the lathe and fine-turned. The next step is to cut the thread on the gun and to screw on the trunnion hoop. The muzzle and breech faces are then faced off to the proper length. The gun is now fine-bored, and the chamber reamed out. The reamer for this purpose is made the exact shape of that part of the bore, and cuts the two cones and the intervening cylinder all at once. The gun is now ready for rifling.

The rifling bar used is five inches in diameter, with a groove cut in it whose twist is the same as that of the rifling. To cut this groove, the developed curve of the rifling is laid off on a horizontal plate at the side of the lathe. A groove is cut along this curve, in which travels a stud, which moves a ratchet gearing into a wheel on the end of the bar. As the bar travels along the lathe, the stud and ratchet move out in the groove, causing the bar to revolve, and the stationary cutter cuts the required groove. The rifling head carrying the cutters is fitted on the end of the bar.

The rifling is done in a planing machine, as there is no special rifling machine in the shops. The gun is laid on the planer table* *b*, supported in a chock, *c*, and carried in a collar, *d*, by which it may be revolved about its axis and a new surface of the bore presented to the rifling tool when desired. On the muzzle end of the planer is a standard, *e*, which passes freely along the rifling bar *f*, and serves as a support to it. It has a stud projecting down into the groove in the bar. As the gun moves forward, the stud, moving in the groove,

*See Vol. XI., Proceedings of the Naval Institute, No. 33, page 337, for drawing and description.

causes the bar to revolve, and the cutters cut a groove in the gun which is a reproduction of the one on the bar. There are eight cutters on the rifling head, and eight grooves are thus cut at once. The grooves are first roughed out all around, and then finished to the required profile with finishing cutters. On account of the difference in the width of the grooves at the breech and muzzle, a second groove has to be cut in the bar having the diminished twist of the reverse edge of the groove. The rifling is finished with this groove and the finishing cutters.

The elevating band is now shrunk on and the screw box for the breech plug cut and slotted out, and the breech mechanism is then fitted.

The slotted-screw breech-closing arrangement was adopted in the Navy in 187 , and is the system used in these guns. It was originally intended to use the cup gas-check, but early in the construction of Gun No. 1 the De Bange system was adopted. In the early application of this system of obturation,* the pad, filled with asbestos and mutton suet, was enclosed between two sets of rings of peculiar cross-section made of tin, copper or other soft metal, or of an alloy. In practice at the Naval Proving Ground at Annapolis, these rings were found, after firing, to stick to the wall of the chamber, and thus to prevent the ready withdrawal of the breech plug. Experience showed the necessity of a harder material, and in June, 1884, the Bureau of Ordnance ordered a pair of retaining rings made of steel. After ample trial they were found to be entirely free from tendency to stick in their seats, and were then adopted as standard. It has been found in firing that the pad itself often sticks badly, making it extremely difficult to turn the plug to the withdrawing position. To remedy this, an important modification has been made in the mechanism—viz.: the spring has been left out, and a frictionless washer has been introduced. This consists (as will be seen in the drawing) of two grooved cups fitting together, the grooves enclosing a number of spherical steel balls, and thus enabling the two cups to revolve around their axis without grinding together. By this means the breech plug can be turned without turning the mushroom and pad, and the pitch of the interrupted screw in the plug is sufficient to start the pad to the rear and free it from its seat. In practice this is found to work admirably, and the plug can be easily turned and withdrawn without the use of the cam.

* See Vol. XI., No. 33, Proc. Nav. Inst., page 336.

The gun is next sighted. Both centre and side sights are fitted. The appended sketch shows the front and rear side sights.

In February, 1884, the 6-inch gun No. 1 was fired for the first time. The charge was of sphero-hexagonal powder, and beginning with 25 pounds, it was gradually increased up to 45 pounds. The velocities increased from 1252 to 1910 f. s., and the pressure from 6.2 to 16.8 tons per square inch. Later, 45 pounds of another brand of this powder gave 1927 f. s. velocity with 17.3 tons pressure, which is remarkably good for black powder, and illustrates the great progress made in the manufacture of powder in this country. In May, with still another brand of this powder, the following results were obtained:

Powder.	Charge (lbs.).	Pressure (tons).	Muzzle Velocity (f. s.).	Projectile.
Dupont's Sphero-Hex. (56)	40	12.8	1825	100 pounds, with copper band 6.12″ in diameter.
	43	14.8	1892	
	45	15.4	1951	
	46	16.2	1970	
	47	15.9	1978	
And later:	44	16.1	1922	100 pounds, with copper band 6.12″ in diameter.
	45	17.2	1948	
	46	16.4	1987	
	45	21.9	1948	
	48	20.9	2005	

This powder was evidently too violent, and gave pressure that no gun could be expected to stand in service. Meanwhile, however, Cocoa powder had been developed in Germany, and the Bureau had ordered an experimental lot from each of the firms—the Westphalian and the Rothweil. This arrived in June, and was fired from the 6-inch gun with the following results:

Powder.	Charge.	Pressure.	Muzzle Velocity.	Projectile.
Cocoa "A," Westphalian.	25	5.2	1277	100 pounds, with copper band 6.12″ in diameter.
	30	6.9	1406	
	35	8.7	1555	
	38	9.4	1624	
	41	10.4	1705	
	43	11.1	1773	
	45	11.7	1808	
	47	12.2	1836	
	49	12.8	1890	

Powder.	Charge.	Pressure.	Muzzle velocity.	Projectile.
Cocoa " B,"	35	10.3	1666	100 pounds, with copper band 6.12″ in diameter.
Rothweil.	40	10.5	1717	
	45	12.7	1841	
	47	13.9	1925	

In October a number of rounds were fired with 50 pounds of C_{82}, the powder adopted for this gun, for the purpose of determining the initial velocity in connection with the preparation of a range table. This resulted in 1915 f. s. being taken as the average initial velocity for this charge.

A number of rounds were then fired with this charge and the service shell at different elevations, with the following results:

Elevation.	Mean Range (yards).
4°	3714
5°	4375
6°	4990
7°	5550
8°	6057
10°	7008

In February, 1885, several shots were fired with increased charges of C_{82}, with the following results:

Charge.	Pressure.	Muzzle Velocity.
45	9.5	1630
50	11.3	1835
52	11.9	1860
54	12.6	1906
56	12.8	1960
58	14.1	2000

As a result of these experiments with Cocoa powder, the powder for the U. S. S. Atlanta was ordered from Germany.

During the past year a series of experimental powders of Messrs. Dupont have been tried, with gradually improving results, until at last a Cocoa powder was furnished by them which in November last gave the following results:

Charge.	Pressure.	Muzzle Velocity.	Projectile. (Weight in lbs.)
50	12.2	1881	100
54	13.2	1928	100
56	13.9	1967	100
58	14.2	2011	100
58	15	2019	101.5

The best result was obtained in July, when 50 lbs. of Dupont's brown Cocoa powder with a 100-lbs. shell gave a velocity of 2011 f. s. with a pressure of 14.3 tons.

The 6-inch gun No. 1 has been fired in all 271 times, with charges varying from 25 to 58 pounds of powder. The pressures have risen to 17 and 18 tons, and on two occasions even to 20.9 and 21.9 tons, per square inch. Of course, as a rule the pressures have not been higher than 15 tons, but it is clear that the gun has at times been subjected to very severe strains, much greater than it could ever have to bear in practice with a well-known service powder. All this has naturally resulted in a quite considerable scoring of the bore. The diameter of the chamber has been permanently increased—to the greatest extent at the forward end, where the increase is 0.014 inch. The diameter of the bore across the lands has been increased throughout, the increase varying from 0.042 inch at the beginning of the rifling to 0.003 inch at the muzzle. The diameter across the grooves at the rear seat of the projectile has been increased to 6.120 inches. The corners of the grooves at the beginning of the rifling have been considerably cut into. In addition, there are shallow scores all along the walls of the chamber, and in the bore for a distance of several feet.

To remove as much as possible the bad effects of this scoring at its worst point, the chamber reamer has been set to work again and advanced an inch and three-quarters farther into the bore. A slight increase in the charge of powder will counteract the effect of shortening the travel of the shot, at the same time giving about the same velocity and pressure.

This gun will be put on board the Dolphin, and when, after repeated firing, the scoring has greatly increased, it may be relined.

The only projectile that has so far been finally adopted for the 6-inch gun is the cast-iron common shell, of which a sketch is here given. It is 3.48 calibre long, and the mean thickness of the walls is 0.47 calibre. It weighs, loaded with a bursting charge of 7 lbs., 100 lbs. These shell have been made in large quantities at the Washington Navy Yard. The expansion band is of the shape shown in the sketch, and has been made of copper tubing and of cast brass. It is forced on by a hydraulic press, and then turned down to size. 6.12 inches is the diameter, and this seems to allow sufficient compression to make the band take the rifling firmly. The following table will show the results of some experiments made with bands of different diameters:

Charge.	Projectile.	Band Material.	Diameter of Band.	Pressure.	Muzzle Velocity.
50	100	Copper tubing.	6.12	11.8	1836
"	"	"	6.14	12.2	1865
"	"	"	6.16	12.2	1865
"	"	"	6.18	13.0	1880
"	"	"	6.20	12.6	1880
"	"	"	6.20	12.5	1880
"	"	"	6.22	12.7	1889
"	"	"	6.24	14.3	1924
"	"	Cast brass.	6.15	12.1	1844
"	"	"	6.12	11.8	1839
"	"	"	6.12	11.8	1826
"	"	"	6.18	12.7	1880

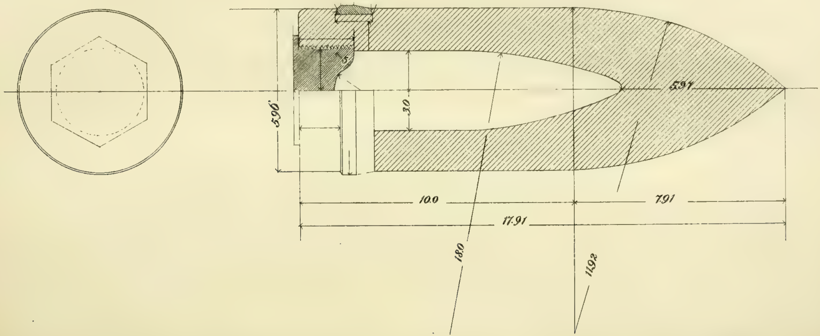
Quite a number of experimental steel shell have been made and tried. The most successful was a chrome-steel armor-piercing shell, the ingot for which was furnished by the Chrome Steel Works of Brooklyn. This shell was manufactured, tempered and banded at the Naval Proving Ground, and weighed 101.5 lbs. It was fired with a charge of 58 lbs. of Dupont's Cocoa powder against an 8-inch Brown compound plate, backed with 20 inches of oak and an iron skin-plate. The muzzle velocity was 2025 f. s., but, unfortunately, the elevating gear slipped, and the shell went over the target into the butt. It was recovered and fired again with the same band, the muzzle velocity falling to 1941 f. s. The shell struck the plate at the point aimed at and remained in the target (the butt protruding seven inches) unbroken, somewhat upset, and badly cracked. The effect on the plate was very marked. A single rent extended through the entire plate to the upper edge. There is a decided bulge, about one inch in depth and six inches in diameter, in the skin-plate, indicating that a segment of the plate has probably been driven some distance into the backing.

These two shots, with the one mentioned before (2011 f. s. with 50 lbs. of powder), represent the best results that have been obtained with the 6-inch gun as regards both powder and projectile, and they are unequalled by any results hitherto attained anywhere.

Special Notice.—Since this article was written, still further progress has been made in the manufacture of Cocoa powder by the Messrs. Dupont, as will be seen by the following remarkable results, obtained at Annapolis with a 6-inch B. L. R. Mark II, and a 100-lb. projectile :

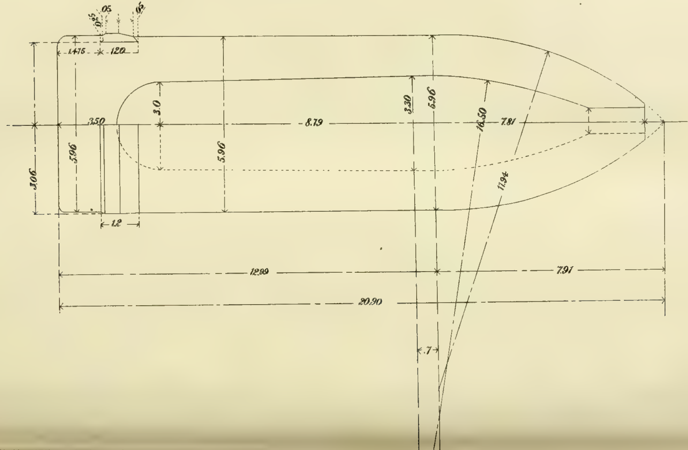
Date.	Charge (lbs.).	Initial velocity.	Pressure (tons).
Feb'y 27, 1886.	50	2029	13.3
March 11, 1886.	52	2052	13.6
	53	2080	15.3
	54	2105	15.6

6in Battering Shell.
(Steel)



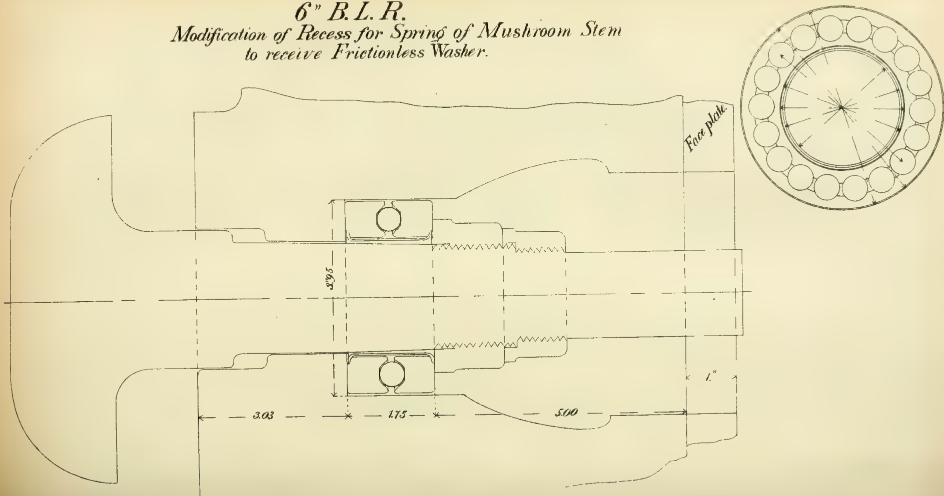
No. 2.

6in Common Shell
(Cast Iron.)

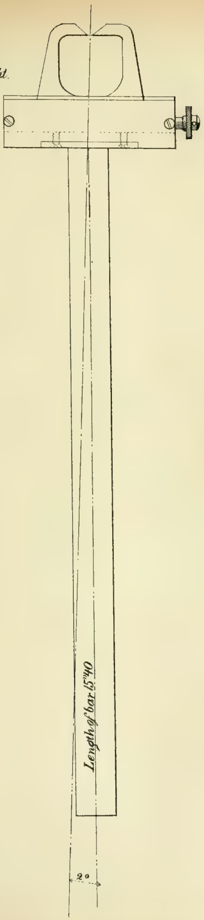


6" B.L.R.

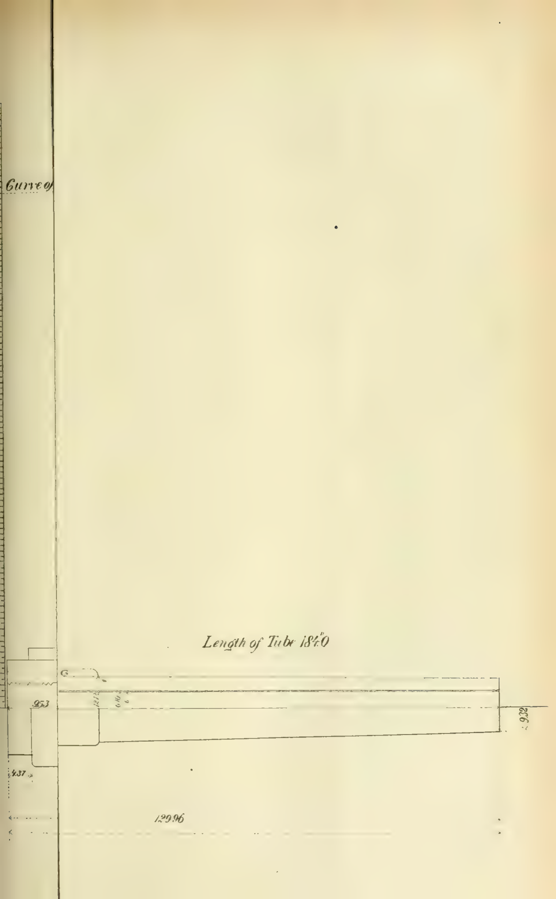
Modification of Recess for Spring of Mushroom Stem to receive Frictionless Washer.

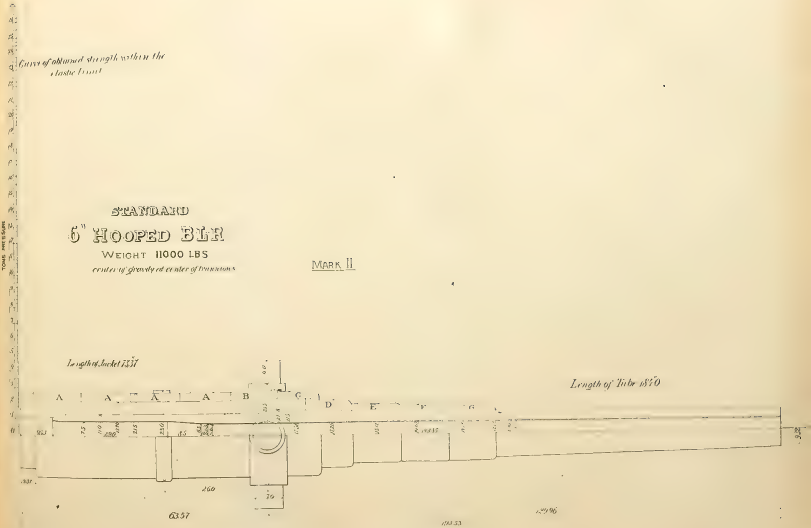


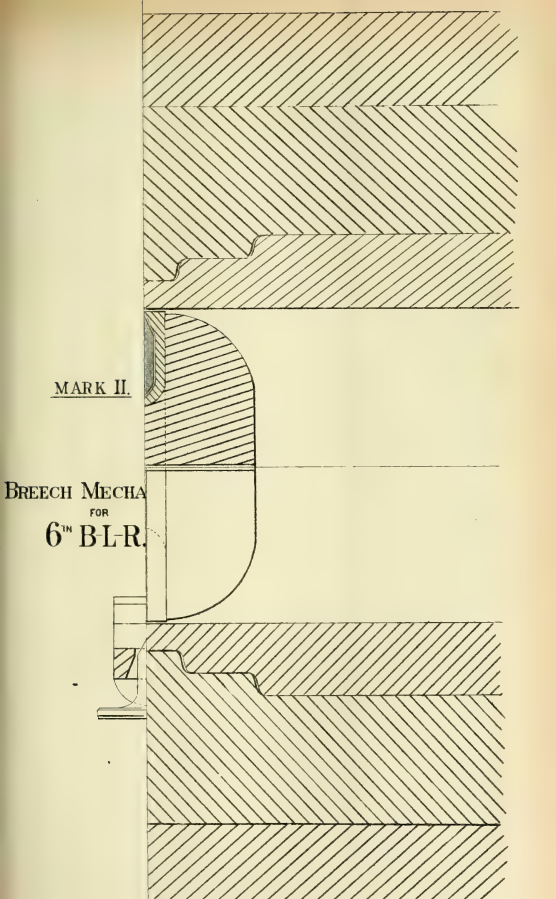
Rear Sight.



Front Sight.

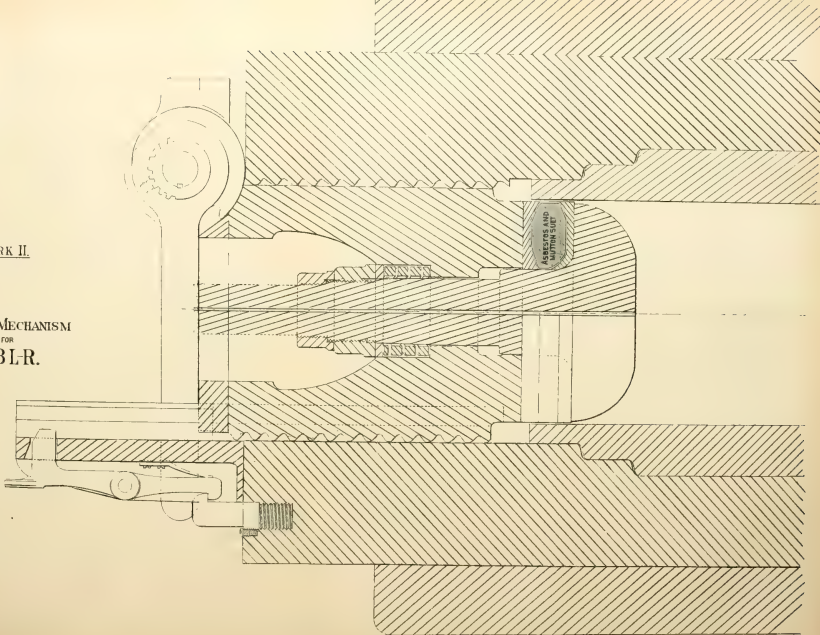

Curve of
Length of Tube 18'0"
G
.953
4.37
129.96
.932


STANDARD
6" HOOPED B.L.R.
WEIGHT 11000 LBS
center of gravity at center of trunnions
MARK II
TONS PRESSURE
Curve of obtained strength within the elastic limit
Length of Jacket 73.37
Length of Tube 184.0
A
A
A
A
B
C
D
E
F
G
260
70
63.57
129.96



MARK II.
BREECH MECHA
FOR
6IN B-L-R.

MARK II.



BREECH MECHANISM FOR 6IN B.L.-R.

U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

THE PRESENT COURSE IN ORDNANCE AND GUNNERY AT THE NAVAL ACADEMY.

By Lieutenant R. R. Ingersoll, U. S. N.

The course in the Department of Ordnance and Gunnery at the Naval Academy having been materially changed within the past three years, chiefly in the manner of imparting instruction and by the introduction of new work, and much interest, coupled with some curiosity, having been shown by a large number of officers of the service as to what is now being done, the writer, with the consent of the Superintendent, will attempt to give a description of the scope of the present course, for the information of the service at large. It will be understood, however, that the present article is not intended as a comparison of the present system with any other which formerly existed, or to invite a discussion of the subject, but is intended solely to gratify the interest which, as before stated, has been excited. It is hoped, also, when it is seen by the officers of the service how much is being accomplished by the young graduates of the Academy, that the older graduates may be stimulated to perfect themselves in this most important study, the value of which cannot be overestimated.

The instruction being practical as well as theoretical — the term theoretical here is used to include all that is taught in the section-room, although it by no means consists of pure theory alone—and since the practical course begins with the lower classes, the section-room instruction being confined to the 1st Class, the former will first be described.

Practical Instruction.

The following ordnance is available at the Academy for practical instruction, and the whole of it is used at some period or another during the four years' course:

Smooth-Bore Ordnance.

A battery of VIII-inch Dahlgren guns, in broadside, U. S. S. Santee.
6 32-pdr. Dahlgren guns, in broadside, U. S. S. Wyoming.
2 XV-inch guns, U. S. S. Passaic, monitor carriages.
1 XIII-inch mortar.

Rifled Ordnance.

1 8-inch M. L. R., Ericsson carriage, U. S. S. Wyoming.
1 80-pdr. B. L. R., central recoil check, " "
1 60-pdr. M. L. R., directing bar, " "
1 60-pdr. M. L. R., " " U. S. S. Standish.
1 60-pdr. B. L. R., " " " "
1 3-inch steel B. L. R., boat and field carriages.
1 37-mm. Hotchkiss revolver cannon.
2 long Gatlings, cal. 45.
1 short Gatling, cal. 45.

In addition to the above may be mentioned 12 3-inch B. L. R. bronze guns, field carriages, which are used for light artillery exercise, and a full outfit of breech-loading small-arms. Detailed instruction is given by divisions, as a rule, and a further subdivision of the work is made, when possible or advisable, by giving separate and progressive instruction to each class of a division; the exceptions being general-quarters and target practice on board the Wyoming, and battalion exercises in which all the cadets engage, and which, all told, consume but 35 of the whole number of instructions during the academic year. The following is the whole number of instructions which each cadet receives in all that pertains to ordnance and gunnery while at the Academy: 1st Class, 100; 2d Class, 123 (including summer months); 3d Class, 90; 4th Class, 113 (including September). In addition may be mentioned all that is taught in this connection while on the practice cruise.

The programme of Practical Instruction and Summary, as published in the Annual Register of the Academy, and which was introduced and put in force by the present Superintendent, shows at a glance the work done by each class throughout the entire course, and the number of instructions in each branch which each cadet receives. This plan works smoothly and admirably, the distinguishing feature, as relates to gunnery, being, as before stated, *progressive* instruction; the simpler and less important duties being mastered in detail by the lower classes, and the requirements increasing in importance to

the end of the 1st Class year. At the same time, enough general exercises are given involving all that has been taught from the beginning, so that the whole is kept fresh in the mind.

The following table gives the whole number of instructions which a cadet receives as infantry or light artillery during the four years:

Kind of Instruction.	1st Class Year.	2d Class Year.	3d Class Year.	4th Class Year.	Total, 4 Years.
School of the Soldier...............				34	34
School of the Company...........	5	6	6	11	28
Skirmish Drill........................	5	5	5	5	20
School of the Battalion, Infantry.	12	13	13	13	51
School of the Section...............				10	10
School of the Battery..............	5	6	6	6	23
School of the Battalion, Artillery.	10	10	10	10	40
Total each Year.................	37	40	40	89	

The 4th Class is instructed during the month of September in the School of the Soldier and School of the Section, so that at the beginning of the academic year the members of the class are ready to join their companies or batteries, and thenceforward take part in the exercises in which the battery, company, or battalion of infantry or artillery engage.

All cadets but the 4th Class have thorough instruction in the use of the small sword and broadsword.

The instruction in the handling and use of great guns begins with the 4th Class; but the detailed instruction for this class is confined to the use of broadside smooth-bore guns. This work is extended to and completed in the 3d Class year, the broadside guns on the Santee being used for this purpose. One division of 3d and 4th Classmen receives instruction at the same time, and as the number of cadets thus employed rarely exceeds two guns' crews, close attention to details is possible on the part of both instructor and cadets. In all, twenty-four instructions are given to each cadet, and time is allowed for the proper performance of all the duties. The general exercises on board the Wyoming, which will be mentioned in their turn, also include the handling and firing of broadside smooth-bore guns; the gun captains and important members being 1st and 2d Classmen.

Next, the 3d Class go to pivot-guns, one division at a time, at

which the instruction is continued in detail as before, using the different types of gun carriages; and each cadet receives eleven instructions at these guns. This work is continued in the 2d Class year by divisions, each cadet receiving six instructions, and with this class ends the detailed exercise with heavy guns, but by no means concludes the practical instruction in their use, as will be seen later on.

The most useful, however, of all the practical instruction in gunnery is the target practice, in which the detailed instruction is given by divisions, each class, as a rule, having different work. This begins with the cadets of the 3d Class, the members of which are first instructed with rifles in the proper method of pointing, a fixed rest being used. The instructor explains the errors which may result from an improper position of the eye with respect to the sights, from an inclination of the rear sight from the vertical when elevation is used, and from other causes, after which gallery practice with reduced charges and targets is given. This practice is extended by divisions to the use of pistols and revolvers, and later in the year a third practice is given at the rifle range with rifles, with the result of constant improvement in the shooting. Each cadet of the 3d Class gets, in all, three weeks' instruction in the exercise periods, firing every day, and in the last practice firing fifty or more rounds.

During the summer months, after passing into the 2d Class, much time is devoted to practical gunnery. Divisions are formed of the class, and each division is separately instructed in the use of howitzers afloat and target practice with howitzers, the steel 3-inch B. L. R. being used, and which includes ten instructions for each cadet; after which machine guns are used, with five instructions for each. Then exercise is given in the handling and firing of the XIII-inch mortar; five instructions for each cadet; and finally each division in turn has target practice on board the Standish. This steamer is fitted with a 60-pdr. B. L. R. pivot gun forward, and a 60-pdr. M. L. R. pivot aft, both mounted on directing bar carriages, and each commanding a large arc of train on each side.

The work is done as follows: The steamer leaves her dock early in the afternoon, steams out into the bay, and a regulation target is anchored. The steamer takes up a position at not over 1200 yards from the target. As this is the beginning of firing heavy guns afloat, the steamer is kept as stationary as possible, and the distance of the target is tested from time to time by a Gatling gun. The range is given to the cadets, who begin firing, ample time being given to

aim correctly, and the errors in range or direction are noted and corrected by the instructor as the practice proceeds. The loading is carefully watched to prevent accidents, and the proper use of the recoil checks is explained and insisted upon. The fall of the shot is recorded by two observers, one on the steamer and one at right angles to the line of fire, and 1200 yards from the target. Each cadet fires at least five shots, on the same day, if possible, in order to correct his errors in successive shots, and he sees about sixty shots fired. The practice is much better than might be expected from a first experience, and the preceding exercises in pointing and firing small-arms, howitzers and machine guns, are undoubtedly of great benefit.

During the academic year the 2d Class again receives instruction in machine-gun practice afloat, a steam launch being used fitted with regulation mounts, each cadet firing 500 rounds or more with the Gatling gun and several shots with the Hotchkiss gun. A fixed target is used, but the practice takes place at full speed, approaching or moving past the target.

The cadet, having become a member of the 1st Class, again has practice at the beginning of the first term with the guns of the Standish, each division taking a week in turn. The plan followed out is for the steamer to leave her dock at 3 p. m., returning about 6 p. m.; and the firing is conducted in most respects like that previously described, but quick shooting, combined with accuracy, is attempted. Each cadet fires at least five shots, and sees about sixty fired.

Finally, in the second term, this practice is repeated, a division of the 2d Class assisting to handle the guns and witnessing the firing. In this last instruction, however, the steamer moves at full speed between two fixed points which are each 1200 yards from the target, and which form with the latter a right triangle. An observer is stationed at each point to note the fall of the shot. The cadets are each required to fire two rounds in succession within three minutes, the beginning and end of that period being marked by blasts of the steam whistle, the guns not being loaded before the first blast is heard. About fifty rounds in all are fired by each division.

On six Saturdays in October and November the whole 1st Class goes on board the monitor Passaic. Steam being ready, the moorings are at once slipped, the monitor steams out into the bay, and exercise and target practice with the XV-inch guns follow. Shell, shrapnel, and canister are used, and from four to six rounds are usually fired

on each occasion. The class is divided into four divisions, one of which in turn goes to the engine and fire-rooms, and the others are distributed to the gun and powder divisions.

In addition to the detailed instruction, all the cadets, stationed as a ship's company, man the Wyoming during the exercise periods of a week, for the purpose of instruction in the duties of "clearing ship for action" and "general quarters"; the time being taken up with preparing the steamer for battle and exercise at the guns, one division of 1st and 2d Classmen going in turn to engine and fire-rooms. On four Saturdays the ship's company goes on board at 8 a. m., and, steam being ready, the moorings are at once slipped and the steamer proceeds out into the bay, clearing ship for action on the way out. Once outside the harbor, target firing begins with the whole battery, the Wyoming steaming around the target. Frequently over thirty rounds are fired before returning to the harbor, the steamer being moored about 1 p. m. While under way on board the Wyoming, Passaic, and Standish, the cadets run the engines, steer the ship, and heave the lead, performing the work of enlisted men.

This concludes the practical instruction in handling and firing guns under service conditions, and at least this much may be said of it—that a cadet who graduates from the Academy after having gone through the whole course, has had instruction with, and has fired, or has seen fired, every class of gun at present in use in the Naval service. In addition to all the foregoing, however, there are certain periods devoted to what is termed practical ordnance. The distinction between ordnance and gunnery being difficult to define, it will suffice to say that many of the things taught in these periods are absolute essentials to the complete education of a gunnery officer, and that the remainder are deemed of great importance, should an officer be called upon to perform ordnance duty. The exercise periods for two weeks are devoted by each cadet of the 1st Class, and for one week by each cadet of the 2d Class, to this work.

The instruction for the 2d Class includes the following:

To dismount and assemble the Gatling and Hotchkiss guns, and to learn the use of each part; to know what to do in case of accidents in firing, and how to clean the pieces; to dismount and assemble small-arms; the nomenclature of service guns and carriages; the construction of ships' magazines; the stowage of powder; to know the use of the different powder charges, projectiles and service fuses. This work for the 2d Class precedes the practice firing with

machine guns. It is so arranged that only two or three cadets are engaged on the same work each day, the subjects being taken in turn; and this applies to the 1st Class also.

With the 1st Class, two or more days are devoted to firing a gun for range, the 3-inch B. L. R. being used for this purpose, and the data thus obtained by all four divisions are used later in the section room, when the method of constructing range tables is the subject for instruction. The gun is also fired for "jump." Next, the Rodman machine is used to find the elastic limit, tensile strength, and ductility of gun metals. Steel and wrought-iron specimens are used principally, and blank forms are filled out for each specimen tested, several specimens being used by each division. Next, the machine is used in connection with the Woodbridge spiral pressure-gauge to construct a pressure curve for use later in the year in determining the pressures in guns. The work also includes the following: taking apart and assembling a full-size model of the 5-inch steel B. L. R.; an examination of the breech mechanisms and various gas checks, including models of those for the new steel guns; star-gauging the 3-inch B. L. R. and taking impressions of the bore; examination of the various powders, including German Cocoa or C_{82} powder, Dupont's brown prismatic and sphero-hexagonal powders; instruction in the contents of the gun-cotton torpedo supply box and the use of the torpedo outfit, and using the inspecting instruments on service projectiles, including those for the steel B. L. R.'s. It should here be added that each cadet of the 1st Class, later in the year, is given five instructions in firing practice torpedoes from a steam launch fitted with the latest apparatus, floating targets being used and attacked under full headway.

Practical instruction also includes the experimental determination of velocities and pressures, but the time is taken from the recitation periods. A firing butt has been constructed in rear of the armory, screens, wires and batteries provided, and a small brick structure has been built to cover the Schultz chronoscope. Various other experiments, involving the measurement of small intervals of time and applicable to gunnery, are sometimes made.

Brief instruction is also given in practical photography as applied to ordnance purposes, dry plates being used. The time being limited, the work is confined to the development of negatives, with some printing, if possible.

The Bureau of Ordnance, Navy Department, has furnished models,

projectiles, material for experiments, drawings and new matter, from time to time, so that the cadets may at least see the latest improvements.

Theoretical or Section-Room Instruction.

Such subjects as it is believed are mastered in the practical work are not dwelt upon, as a rule, in the section-room, and if introduced there, the object is to freshen the memory or to emphasize important features. It is thought that the scope of the section-room instruction will best be understood by a brief description of the subjects covered by the text books. These are:

The *Ordnance Instructions; Text-Book of Ordnance and Gunnery, Naval Academy Publication; Hand-Book of the Hotchkiss Rapid-Firing Gun, Very; Exterior Ballistics, Naval Academy Publication; Elastic Strength of Guns, Naval Academy Publication; Work of Gunpowder in Guns, Sarrau; Probability of Hitting an Object of Any Form, Bréger; Examples in Interior Ballistics, Lt. Meigs, U. S. N.; Ordnance Notes, Printed Notes, and Extracts from Official Reports.*

Some of the above are small pamphlets.

The general rule is to combine descriptive matter with the mathematical work concerning the construction and use of ordnance or ordnance material, when possible, and usually the former precedes the latter.

The *Ordnance Instructions* and *Text-Book of Ordnance and Gunnery* are not completed then at any one time, but parts are selected as may apply to the subject in hand.

Taking the text-books in turn:

The *Ordnance Instructions*, as the official source of information, are used so far as possible for the description, rules, exercises, etc., as applied to the service of guns and the care of ordnance material, the parts concerning rifled guns being considered of most importance.

The *Text-Book of Ordnance and Gunnery*, which is not a complete treatise in itself on these subjects, is intended to supplement the *Ordnance Instructions* with descriptive matter, and to supply in convenient form many things which would otherwise be taught from MS or from notes. In brief, the book contains a description of the properties of gun metals; a description of modern guns and their manufacture, including the new steel guns; the principles of the Vavasseur gun carriage; a description of the machine guns and their

uses; a description of explosives and their manufacture. It also describes the kinds of armor in use, and gives formulas for penetration; contains chapters on the principles and practice of naval gunnery and the rotation of rifled projectiles; touches briefly on torpedoes and field fortifications; and a chapter is added defining the duties of junior officers of divisions. In connection with the subject of machine guns, the *Hand-Book of the Hotchkiss Rapid-Firing Gun* is used.

Exterior Ballistics.—With this book the cadets are taught the theory of the sight-bar, which involves the computing of the permanent angle at which the rear sight-bar is set to allow for drift due to rifling; the marking of sight-bars for various ranges, and the effect on deviation from the line of fire of the position of the rear sight-notch when it is moved laterally. The motion of projectiles in a vacuum is then taken up, and in this connection is shown the practicability, within certain limits, of the use of sight-bars which are marked for ranges on a horizontal plane through the gun, when firing at objects above or below that plane, as is almost always the case in practice. Next in order is the study of the resistance of the air to the motion of projectiles, and then follows the mathematical work necessary to compute trajectories of projectiles in air. Next is shown the effect of the wind, motion of gun and target on the flight of projectiles, and the method of correcting the fire of guns for such errors is taught. Then follow the preparation and use of range tables, in which the data are those found by the cadets themselves with the 3-inch B. L. R. In all of the foregoing, practical examples are introduced, and some recitation periods are devoted to practical work alone.

Elastic Strength of Guns.—The theory of the computation of the strength of homogeneous and built-up guns is taught with this text-book, as well as the shrinkages in the case of built-up guns, and the compression of the bore when the gun is in a state of rest. Examples of guns in use or designed for our service are used in the application of the theory to practice. While on this subject, the cadets are required to make a scale drawing of one of the new steel guns, and to compute and erect over it the line of elastic strength for the whole length of the gun. This drawing comes in play later.

Work of Gunpowder in Guns. Examples in Interior Ballistics.—These are used to teach the method of the computation of the force of explosives developed when fired in their own volume or in a closed receptacle, in order to apply it to determining the force of

bursting charges in shells or torpedoes. The deduction of the equation of the motion of a projectile in the bore of a gun when powder is so fired, and also when powder burns progressively, is also taught, and the theory applied to guns in our service. Then follows the computation of muzzle velocities and pressures when the quantities known are: the density of loading, weights of charge and projectile, calibre, and the travel of the projectile in the bore. The effect of small variations of the elements of loading, and the influence of the shape, size and density of powder grains on velocities and pressures, are also taught. The *Examples in Exterior Ballistics* illustrate each of the foregoing subjects. Several days are devoted to practical work alone, in which, near the end of the course, the cadets are required to compute the elements of, and to erect a pressure curve over the bore of a gun, the scale drawing previously mentioned being used for this purpose. Valuable and instructive data are frequently furnished by the experiments at the Naval Ordnance Proving Ground for use while on this subject.

The Probability of Hitting an Object of Any Form.—The object of this study is primarily to teach the cadets the effect produced in gunnery practice by errors of whatever kind, as shown by the probability of hitting targets of various shapes and sizes, the errors being taken from practice firing when available, with the idea that, understanding the effect, the intelligent officer will use every effort to eliminate the errors whenever possible. That this object is realized, is established beyond a doubt. The application of the theory is extended to fire against ships; to taking up distance from targets of known size and form, and to the determination of the supply of ammunition necessary to accomplish a certain number of hits. This last is of growing importance, when the question of the cost and limited supply of ammunition for modern guns is considered. Practical examples are constantly introduced, and more attention is paid to the application of the various formulas than to their deduction.

In addition to the text-books, Ordnance Notes, printed or in manuscript, are used when engaged on the subjects involved, among which may be mentioned the "Recoil of Gun Carriages," "Gun Designing," by Colonel Maitland, R. A., "The Heavy Guns of 1884," also by Colonel Maitland. Extracts from the Official Reports of the Bureau of Ordnance, Navy Department, are also used when applicable, and every effort is made to keep the instruction up to the progress which is being accomplished in ordnance and naval gunnery.

Each cadet is required to keep a note-book containing all the examination papers (examinations take place monthly), practical examples, notes on practical ordnance work, and such other matter as may be given him for instruction or reference.

In conclusion, it should be said that the cadets take hold of the work with great interest, and, with their mathematical knowledge fresh in their minds, find no difficulty in getting an excellent idea of what, at first sight, seem to be complicated subjects. Undoubtedly they can master them in a much less time now than they could at a later period in life, when, in many cases, they would not be so ready with their mathematical knowledge; and, further, it may be said that the studies involving ordnance matters pure and simple do not interfere with the acquisition of the practical knowledge of the duties of a gunnery officer, which is mainly taught, not in the section room, but by the actual use of the guns. Appended are samples of examination and practical example papers.

APPENDIX I.

Department of Ordnance and Gunnery.

Practical Example, February 11, 1886.

The 8-inch M. L. R. is fired with a 180-pound projectile, at an angle of departure of 10° and a muzzle velocity of 1450 f. s. Find the range on the horizontal plane through the gun. The gun being mounted 20 feet above the water, it is required to mark the side sight-bar for use in firing at an object in the water at a horizontal distance equal to the above range. The jump angle is $+25'$, the permanent angle for deflection is $1° 50'$, the distance between sights is 45 inches, and the rear sight is at right angles to the axis of the bore.

APPENDIX II.

Department of Ordnance and Gunnery.

Semi-Annual Examination, January 26, 1886.

1. Give the Manual in full detail at the orders, "Serve vent and sponge," and "Load" with a 60-pdr. B. L. R. State what is done if the breech is difficult to open, if a miss-fire occurs, if the breech will not lock. What cleaning of breech mechanism is necessary after each round?

2. Name the kinds of powder in use in our Naval Service. What is the proportion of ingredients? How is powder supplied to the gun from a ship's magazine? What general rule governs the number of chains of scuttles? How many light boxes are necessary for each magazine? What is the test for dampness in magazines?

3. What kinds of shell are used with rifled guns in our service? Which are fused, and with what kind of fuse? Describe the fuse used with the 3-inch B. L. R. shell. The length of a B. L. R. battering shell is 17.41 inches, the length of the ogival head is 7.41 inches, and the diameter of the cylindrical part is 5.96 inches: what is the radius of the ogival?

4. In gunnery practice, define "mean lateral deviation," "mean lateral error," "mean absolute error," "mean error in range," "jump," "dangerous space," "clearance angle," and "radius." Make a sketch showing what is meant by the terms, "line of sight," "line of departure," "angles of elevation, projection, sight, departure, and jump."

5. A 3-inch B. L. R. gun is sighted by means of a line of sight in the axis of the bore at a point on a vertical screen distant 50 feet horizontally from the muzzle of the gun. The gun being loaded and fired, it is found that the point of the projectile hit the point aimed at IV = 1000 f. s.; is there any jump? If so, how much? The radius of a gun is 50 inches, and a projectile which leaves the gun at an angle of departure of $5°$, the angle of sight being $+15'$, and the jump $1°$, falls at a distance of 1500 yards on the plane through the point of fall and the gun, and the deviation due to rifling is 10 yards to the right. What inclination from the vertical should be given to the sight-bar, to correct the drift? What is the distance set off on the sight-bar for the 1500-yard mark, when so inclined?

6. Describe the means used in checking the recoil of gun carriages when fitted on the Vavasseur principle. How, in the gravity return carriage for 6-inch B. L. R., is the recoil checked? How is the gun returned to battery? How is the gun held in battery in a sea-way?

7. The recoil of a 6-inch B. L. R. is restrained by an hydraulic cylinder alone. Weight of gun and carriage 13,000 pounds, projectile 100 pounds, charge 50 pounds, and value of $C = \frac{1}{2}$. Initial velocity of projectile 2000 f. s. Effective area of piston 30 square inches. Weight of cubic foot water 62.5 pounds, and recoil to be limited to 20 inches. The pressure is to be *constant* in the cylinder, and the aperture of escape of liquid *variable*. 1st. What is the initial area of aperture? 2d. What is the area when the gun has recoiled 18 inches? and what is the pressure in the cylinder?

8. A navy regulation target presents a vertical triangular surface h feet high and $2b$ feet base. The extreme errors of a gun are m and n feet horizontally and vertically respectively: what is the probability of a single shot hitting the target when the mean point of impact is taken at the middle point of the water line?

9. How may the principles of probability be applied to regulate the fire of guns on board ship? Of 15 shots fired at target practice at a supposed range of 1500 yards, four fall short and five to the right. The mean error in range is 85 yards, mean lateral error 10 yards, and the radius of the gun 50″. How should the sight-bar be set, and how should the sight-notch be moved in order that, in the next series of rounds, the point of mean impact and the target shall coincide?

10. An enemy's vessel has two exposed guns, each of which with its crew presents a vertical rectangular target six feet high and eight feet wide, and both are on the same deck. The targets are 36 feet apart, thus, 6′ $\boxed{8'}$ ....36′............ $\boxed{8'}$ 6′, and the mean errors of two Hotchkiss guns, which are directed to fire on them, are in direction 10 feet and in height 6 feet. Which of the two following methods, at the range used, will show the greatest probable number of hits on both targets after a given time—viz., to direct the fire of one Hotchkiss gun against the middle point of each target separately, or to direct the fire of both guns at the middle point between the two targets, with a chance of hitting either? Each Hotchkiss gun fires in the same time the same number of rounds, and the mean point of impact is assumed to coincide in both cases with the point at which the fire is directed.

THE USE OF ONE ANGLE IN CURVED CHANNELS.

By Commander H. C. Taylor, U. S. N.

Before describing the "use of one angle in curved channels," it may be well to say that the principle is a very old one. It has been applied in different ways, and is used in the "danger angle," mentioned in *Sailors' Horn Book* and Harrington's *Navigation*, and is well known to all navigators. The principle used in navigating narrow and curved channels is the same as the danger angle, but applied under slightly different circumstances. It is the danger-angle idea somewhat amplified. It had been used in the C. S. Steamer Hassler and in the U. S. S. Saratoga for several years of occasionally difficult navigation and piloting, when it occurred to me that its use was not general in the Navy; and finding, upon inquiry and discussion, that it was but little known or used for curved channels, I described to the Department the convenience I had found in employing it, and suggested further trials of it at various entrances on our coast. A Board appointed in the Navy Department to examine the subject reported favorably as to its probable value in practice.

This method is applicable in entering many of our coast ports. Among these may be named: Portland, Salem, New Bedford, Oyster Bay, Sandy Hook, Patuxent River, Key West, and others. At Sandy Hook, where the ranges are, most of them, a long way from the channels they mark, slight mists are sufficient to cause them to be obscured, and at the same time to cause confusion as to the buoys; while a curve passing through Highland Light and Scotland Light Ship may be found useful to carry a ship safely from the Scotland around the Hook, and into the anchorage inside the Hook. And if this method should find favor, greater security and convenience could be reached by the erection of one or two beacons at suitable points of a good curve. The reef at Key West offers several examples of curved entrances of much safety and convenience.

The principal objection to the general use of this method is the ignorance of the use of the sextant and of the measurement of

horizontal angles among a majority of seamen and officers in the coasting trade and merchant service. Here, again, if this method proved useful, a simple and cheap instrument could be made, without a movable arm, and registering permanently one angle—namely, the angle of two known objects in the vicinity—which, being kept at the proper number of degrees, would ensure a ship being on a safe curve. The objects and their proper angle being carefully determined practically for each port, these simple instruments would be constructed bearing the names of port and of objects used, and the number of degrees of angle.

All these matters are consequent upon the method being found useful; and I recommend the use of this method to officers, not as being certainly valuable, but as worthy of being thoroughly tested. I have had occasional incomplete trials of the method at San Juan de Porto Rico, Key West, Oyster Bay, Sandy Hook, and on the Pacific Coast, but have been at those times engrossed with survey work or the training of apprentices, and unable to give sufficient attention to the method. It should be understood that no new principle is claimed, and the only point specially made is that its application to curved channels may be found, in certain ports, very useful and convenient.

Upon approaching a harbor or channel where piloting becomes necessary, and where this method promises to be of use, identify on the chart some prominent points or objects in the vicinity of the curved channels to be followed. Then note what general curve the ship's course will have to follow in the channels, and describe roughly a circumference, of which this curve shall approximately be an arc, and which circumference shall pass through two of the prominent points or objects recognized on the coast. A headland, or simply a marked bend in the land, may be used in default of better-defined objects, the angle being taken to the tangent of the point, if the bends or profiles are sufficiently salient to prevent large errors by the change in the point of tangency as we advance. It is rare, of course, to find the exact curve desired, but by trying different known points on shore, and different lengths of radius, a convenient curve can be frequently found which will answer all the purposes of safety. This being done, draw lines from any one point of the circumference to the objects through which the circumference has been passed. The angle made by these lines will be constant for all points of the curve which lie in that arc of the circumference, as all angles in a circumference subtended by the same arc are equal, and as this angle will

in all cases be subtended by the opposite arc connecting the two points.

Thus, if a ship so direct her course as to make this angle (between the two objects) the number of degrees required, and keep it unchanged, or nearly so, she will be constantly on, or nearly on, the circumference referred to; and, as the angle becomes less, she will know that she is passing outside of that curve, and, as it becomes greater, that she is passing inside of it. If we have to round shoals in entering a harbor, *B*, we make, first, satisfactory curves for the

ship to describe in clearing them, such as *M;* then seek for a circle whose arc shall approximate to this curve and which passes through two prominent points, or any objects readily recognized, such as *H* and *P;* such a circle would be *M'*. At any point on the arc between *H* and *P*, lines drawn from *H* and *P* to meet in the circumference will make a certain angle—103° in this case. Hence, by approaching these two objects on a safe bearing until their angle, as measured from the ship, becomes 103°, we will find ourselves upon this safe and convenient curve, which we may follow by edging out when we increase our angle above 103°, and by edging in as it becomes too small. The same way with the next curve, and so on throughout.

There are many cases where the shoal does not discover itself by breakers or discolored water, and when distances from the shore must, without this aid, be judged by the eye—a dangerous plan for strangers unaccustomed to the appearance of the shores, heights of cliffs, and

such details. In such cases, if recognizable ranges back of the anchorage B, or of the point C, are not to be found, the convenience of this one-angle method becomes apparent; while, if to these circumstances we add the existence of a shoal D, or of rocks, as shown on the side of the channel, this method becomes more than convenient, being a valuable guarantee of safety. This is especially true when, in narrow waters and sharp bends of channels, time will not permit of bearings of objects being taken and plotted (the ship might ground while waiting for a position); and a principal virtue of this method is that the chart-work proper is done beforehand, and the officer is left free to handle his vessel with this check and guide always at hand. The sextant, set to the angle required, may be used by the officer himself who is conning, or by his assistant, and the ship may thus with ease and confidence be steered upon a safe and convenient curve or succession of curves.

The principle already mentioned can be extended by the further use of other objects on the same side, defining other curves and making a continuous safe course throughout. Also, if the proper course becomes of reverse curvature, objects on the other side of the channel may be used for defining by their angle a reverse curve for continuing the course; or such reverse curve may be used as a help to the first curve in a difficult passage.

The centre and radius of the required circumference are best found by inspection. Let the eye determine roughly the kind of curve needed to pass comfortably through the dangers; then sweep the arc most like that curve, using the centre and radius which seem needed for it; then search in the vicinity of that portion of this circumference which passes over land and among known objects for two suitable points. Having found these, endeavor so to adjust the centre and radius that the circumference, while fulfilling its office as a safe curve through the dangers, shall also pass through these two points. There will be found, as a rule, but little difficulty in doing this in cases where this method is useful. The angle made by lines from the two objects to a point in the circumference should be between 40° and 140°. It is not so reliable between 20° and 140°, and between 140° and 160°, and it had better not be used when less than 20° or more than 160°.

Should this method, in practice, find favor among officers, and be approved by the Department, the labor of inspecting the charts, describing the most convenient and useful curves, and providing rules for following out these methods, would naturally fall upon the

officers who superintend the preparation and issuing of charts, and would simply be an *addition* to the sailing directions of certain ports where this method promises usefulness. It should be tested practically at the place before directions are written. The work of inspection of the chart beforehand, and of preparing the curve, would not be required of the navigating officer of the vessel, who would only need to accustom himself to the measurement of horizontal sextant-angles. It is also probable, in the case of this method being favorably considered, that beacons or other marks for day or night would be erected in such localities as do not offer at the proper vicinities prominent and distinctive characteristics for use in defining by their angle convenient curves for piloting through a channel.

This method is productive of much satisfaction in the advantage it gives of being able to take the sextant or similar instrument with which one's position or curve is to be determined, to all parts of the ship and use it aloft or on deck with equal ease and accuracy. This advantage of the sextant over the compass is very marked when distant lights or other objects are shut out by mangrove swamps or scrub growth on flat lands, making them invisible from deck, but in sight from tops of an ordinary vessel. Such ports as Key West and Charleston, S. C., are instances of the above.

It may be well to state that this plan cannot be of service in piloting through straight channels, in which ranges and bearings are alone of service. It is useful only where the course to be steered is curved; nor is it of use when this curve is very slight, as in such cases the angle of the objects would be too great or too small, or their distance too great for accuracy.

Many harbors do not need curves of this method, being already well supplied with range lights, day marks, etc.; and it is not intended to be understood that this method should supplant other methods of running on ranges, bearings, etc., but only that it may be a valuable auxiliary to those methods on some charts, and an invaluable substitute for other methods on charts which do not possess the proper lights and ranges, and where curved channels have to be followed.

The writer of these notes is, however, disposed to believe, if the method be found worthy of adoption, that, in many already well-lighted and marked harbors, economy in the number of marks will be obtained by substituting this method in certain cases. An example of this is to be seen in the main ship-channel near Sandy Hook, where by using this method one lighted beacon at the "Dry Romer" would make unnecessary the following—viz.: West Beacon,

Bayside Beacon, and Wilson's Beacon. But the writer wishes to disclaim any intent to propose any changes in existing methods, and brings forward this notice only with reference to its auxiliary character in most ports, and to its own intrinsic value in other cases of ports not marked or lighted properly, or perhaps not at all — such, for instance, as San Juan de Porto Rico, where the writer has found the method very valuable at moments quite critical from a piloting point of view.

Application of the One-Angle Method to the Chart of Sandy Hook.

The chart of Sandy Hook entrance shows (see plate opposite) a curve marked A, defined by preserving the angle of 46° between Highland Lights and Scotland Light Ship. This curve carries 23 feet through South and Main channels.

Another curve marked B is defined by an angle of 86° between Hook Beacon and Scotland Light Ship, and carries 24 to 25 feet through the Gedney channel.

Another marked C is defined by an angle of 73° between Scotland Light Ship and Sandy Hook Light, and carries the same drafts through the Gedney.

Many other convenient curves suggest themselves here, by the use of the lights, light ships, and beacons already in place, and the erection of one or two more beacons in suitable places at slight cost.

The distance of the range beacons from the vessels using them causes them, in most weathers, to be of little value, and it would be a satisfaction to the navigator to have close at hand, upon Sandy Hook, large, easily seen guide beacons by day, and bright guide lights at night. For instance, the curve marked C through Gedney's channel could be followed with ease and exactness by erecting a beacon at a point on the southern part of the Hook, which I have roughly marked X, and keeping the angle between it and Sandy Hook Light 32° (about).

Entering by Gedney and Main channels, when we consider the search for entering buoys at night, the compass courses, influenced by currents of which we are ignorant, and the ranges of far distant lights, usually confused by mists, such an accurate and convenient method as here described will seem preferable to many, especially to those to whom the rough measurement of angles is not a mystery.

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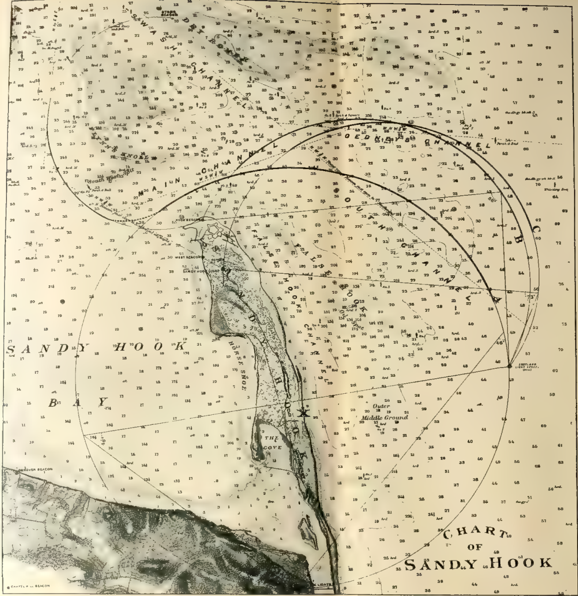


CHART OF SANDY HOOK
SANDY HOOK BAY
MAIN CHANNEL
SWASH CHANNEL
GEDNEY CHANNEL
SOUTH CHANNEL
FALSE HOOK
HORSE SHOE
THE COVE
Outer Middle Ground
WEST BEACON
SANDY HOOK LIGHT

U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

THE MONITOR WEEHAWKEN IN THE REBELLION.

By B. W. Loring, Late Lieutenant, U. S. N.

The following letters of Mr. Loring, being replies to inquiries addressed to him, are now published with his permission. These letters are so graphic, and so clearly describe the peculiar nature and dangers of the service upon which he was engaged in the Weehawken, that it has been considered better to publish them as they stand than to attempt to draw from them the material for a more connected essay.—Editing Committee.

Gentlemen :—The request that I should furnish an article of my experience and observations while on board the Weehawken during her service in the late war—her behavior at sea, the life on board, the manner of handling her guns, and an account of her engagements—I am happy to comply with.

On January 21, 1863, the Weehawken left New York for Norfolk, Va., in command of the late Rear-Admiral John Rodgers, and during this passage encountered her first storm, which nearly terminated her career at its commencement. Arriving off Sandy Hook in the afternoon, it was apparent that an easterly storm was gathering; but having received orders to proceed, if possible, we got under way, were taken in tow by a small, side-wheeled steamer, and, accompanied by the Iroquois, put to sea. The wind continued to increase, and as night approached was blowing a moderate gale. The towing steamer plunged heavily, and made signal of distress. She was ordered to cast off and seek a harbor. We understood she reached Delaware Breakwater in a sinking condition. The sea commenced washing over the deck to a considerable depth, and developed numerous leaks, small individually, but large in the aggregate. The centrifugal pump was not finished, and we were obliged to depend entirely upon the ordinary bilge and hand pumps, which were incapable of discharging the accumulating water. At 2 A. M. the 22d, the engineer reported "the water nearly up to the fires, and only ten pounds of steam on." By extra exertion, steam was sufficiently increased to work the pumps more rapidly. At 4 A. M. signal was made to the Iroquois advising her of our dangerous condition, but she could render us no assistance in that heavy sea. All that could be seen of us was an occasional glimpse of the small light that

hung from the staff above the turret, and each disappearance below the crest of the waves it was thought would be final. During this time, by increased working of the pumps, the water had been kept down, and at daylight the wind had moderated, and continued to decrease until all danger was passed. By noon, with some difficulty, we were able to take a hawser from the Iroquois. At night we passed Cape Henry, and anchored in Hampton Roads. The anxieties of that night can never be forgotten. In speaking of it afterward, Captain Rodgers said, "It added one year to my age."

Previous experience on board this class of vessels would have enabled the officers to prepare better for heavy weather; the numerous openings liable to leak would have received attention, not being difficult to close in smooth water, but inaccessible with the "green seas" sweeping over the deck. The principal leak was at the turret base : a small quantity of water entered at the hawse-pipe, and some around the hatch coverings. During the gale the vessel was kept upon her course, following the light of the Iroquois ; the combs of the sea swept the deck, but not the turret top : only occasional sprays were thrown over it. The experience of this passage was used in preparing for the next one. The centrifugal pump was completed ; places where leaks had developed were carefully attended to. A rope grommet (a rope with an eye-splice in each end hove taut with a lanyard) was tightly drawn around the turret base.

On the first day of February, in tow of the steamer Lodona, we proceeded again to sea, bound for Port Royal. The Lodona was an English propeller captured at Ossabaw Sound while attempting to run the blockade, and was supposed to be capable of withstanding any storm. We encountered a gale from SE. when off Cape Hatteras, during which the Lodona was unable to steam ahead, and being compelled to lie-to, it was considered best to cast off the towing hawser. This was ineffectually attempted at our end, and a courageous seaman volunteered to cut it. With life preserver and bow-line around him, he reached the bow, and, between the seas that washed over him, essayed several ineffectual strokes ; but, losing his axe, was dragged back exhausted to the turret. Captain Rodgers refused to permit the end at the Lodona to be cast off, there being danger of its fouling our propeller, so the vessels remained attached during the gale. No inconvenience was felt from leaks, as the centrifugal pump now cleared the hold of water. The new engine, not having been thoroughly tested, caused us some anxiety, and when within one and a half hours' run of Port Royal the cylinder head broke into fragments. The Lodona, however, towed us safely into port.

I have been explicit in describing these storms, that their severity might be comprehended. The behavior of the Weehawken was admirable, fully establishing the ability of her class of vessels successfully to combat severe gales. In lying-to, her manner was as different from that of the usually modeled sea-craft as there is difference in their models. Her easiest and safest position was to lie in the trough of the sea, rather than head to it, as she rolled like a raft, making splendid weather of it. Her motions were remarkably graceful and easy, and no precautions were necessary to secure the table crockery. The area of surface exposed to wind was small, and her drift to

leeward was unusually slight. The second storm was much more severe than the first, but, being properly prepared for it, and the centrifugal pump being able to discharge all incoming water, we passed through it successfully. In this, as in the previous storm, the heavy seas swept over the deck, and only spray over the turret top. At sea, the anchor and propeller wells are uncovered, leaving a free passage for water. When in tow, this open anchor well, on account of its close proximity to the check through which the towing hawser leads, is a great source of danger to life and limb, as one is liable to be swept into it while examining the hawser for chafes. A life line stretched from the turret to the bow is a necessary precaution, as the combers that sweep the deck, although appearing light, are deceitful.

While upon this subject, permit me to suggest that the sea complement of officers should be in excess of the usual number, as the disability of one or more officers would materially increase the duties of the remainder, and this condition of affairs is very likely to occur. For example, one night, while lying at Norfolk, an alarm that "rams" were coming down the James created a commotion, during which Captain Rodgers was severely injured by stepping into the propeller well. It was two weeks before he was sufficiently recovered to appear upon deck. During this time the executive officer was confined to his room by sickness, another officer, while examining the towing hawser, was swept into the anchor well, went through and came up outside, and was dragged on board severely bruised, rendering him unfit for duty. In this way the complement of officers was reduced from five to two. Consequently, the duty of taking the ship from Norfolk to Port Royal devolved upon the remaining two officers.

The Weehawken's engagements with Forts Sumter and Wagner, and the Sullivan's Island batteries, were numerous, but only those wherein her services were conspicuous need be mentioned. On April 7th, arrangements were completed for an attack upon Sumter. Orders were given to get under way at 2 P. M. The Weehawken was designated to lead the line of battle. Mr. Robert Platt, a gentleman connected with the Coast Survey, and thoroughly acquainted with the topography of the harbor, gallantly volunteered to take the responsibility of piloting us into the engagement. We were provided with a "torpedo catcher" (a raft with trailing grapnels), which caught our anchor chain, detaining us two hours, and proved of no benefit to us. While steaming up the harbor, the following instructions were given the crew of the turret division: "Should we be struck by a torpedo, not a man shall leave the turret until every avenue is free for the escape of your shipmates below deck. Open the slides above; throw back the port-stoppers; run in the guns, should they be out; open all gratings under your feet; then you may leave the turret, not before."

As we approached Sumter, suspicious-looking buoys, indicating torpedoes or obstructions, were reached; the advisability of passing them was considered by Captain Rodgers, and the conclusion arrived at was thus expressed: "Torpedoes! Well, heaven help us if they are, for I am going over them." A few moments later a torpedo exploded alongside, throwing a column of water into

the air, but only jarring the vessel. Having steamed a few hundred yards beyond, it became evident we had reached the focal point desired by the enemy. The initial gun was fired from Sumter, and the first shot struck our turret; then from all directions came a shower of shot and shell; turret, pilot house, smoke stack, side and deck, all came in for their share. We opened fire, still advancing toward Sumter, and were enveloped in smoke and water. General Hunter, who witnessed the fight, in a letter to Captain Rodgers thus describes the scene:

"The Weehawken opened; she was enveloped in smoke and water; we saw the shot like hail flying upon and around her; she was for a moment invisible. Nothing can stand such fire. We held our breath; she came to view and fired again; three cheers, and we breathe freely again." Meanwhile, "we can see nothing: Sumter is invisible; the enemy's shot is throwing water in torrents over the turret; the gun vents are covered; we are not drowned, but very wet. For nearly half an hour this concentrated fire was upon us; we had fired two rounds, and were prepared for the third, when the engagement became general. After an engagement of two hours the signal 'Withdraw from action' was given."

During the concentrated fire, a large shot struck the gun-metal base rim of the pilot house, and breaking out a fragment, jammed the turret, and caused difficulty in revolving it. A few revolutions, however, relieved it. After the action the shot was found upon the turret top, slightly flattened, but unbroken.

To prevent the entrance of broken shot and other substances at the turret base, a hawser and smaller rope had been drawn around it above the plate rim, and after the engagement became general, a hasty examination outside found these, and the rim also, severed, making an opening into which the small rope was tightly jammed. As this was liable to interfere with the working of the turret (unsuccessful efforts having been made from the outside to free it), it was passed in, and finally disengaged by attaching the shot tackle.

The effect of this engagement upon the Weehawken was slight; for although between fifty and sixty shots were marked upon her, no serious damage was received. Numerous bolts in the turret and pilot house were broken, one in the pilot house breaking through the sheet-iron lining. This lining, an idea of Captain Rodgers, was put in at Port Royal at his suggestion, and no doubt was the means of saving life.

The monitors Nahant, Weehawken, and gunboat Cimmeron, on June 17th, were lying in Wassaw Sound, with banked fires, and cables prepared to slip, waiting to intercept an iron-clad ram, reported at Savannah, and about ready for sea. The previous afternoon, four discharges from heavy guns were heard, which came from the Atlanta, who was scaling her guns. The Atlanta, commanded by Captain William Webb, was the English blockade-runner Fingal. She was reconstructed at a cost of about a million dollars, furnished by the ladies of Savannah from the sale of their jewelry and silver, and so bore the name of the "Ladies' Gunboat."

While steaming down the river, they spent the night in making ready for the morning attack. At daylight three steamers hove in sight. The order "Spread

fires, beat to quarters, clear ship for action," caused an amount of activity that in ten minutes found us fully ready for business. Lying in a narrow channel, and heading down the sound to a strong flood-tide, necessitated our steaming into wider water to turn to meet the coming ship (the other two steamers, loaded with spectators to witness the fight, remained above). Meanwhile several shots were fired from the Atlanta. While turning we dropped our small boats with a kedge, and when within three hundred yards of her opened fire. The XV.-inch shot struck at the forward end of her casemate, smashing a hole 3 feet by 1½ ; it was then deflected by the angling side and, passing over, struck a pile of lumber stowed upon the casemate, filling the air with flying boards, and giving us the flattering impression that the whole institution had "gone up." Two guns' crews were wounded by splinters, and prostrated by the concussion. In two and a half minutes a second round from both guns was fired. The XV.-inch missed, but the XI.-inch struck the top of the pilot house, wounding the three pilots, and piling them upon the trap-door, the only entrance to the pilot house. This left the Atlanta without helmsmen, and she went aground upon the shoal along the edge of which she was running. Another round was fired by us from both guns, one shot tearing away a port-stopper, the other striking the knuckle of the overhang. The Atlanta then surrendered.

The Comte de Paris, in his work upon our "Civil War," and also the correspondents who reported this engagement, stated the guns to have been "fired by Captain Rodgers." As officer in charge of the turret division, all guns were fired by myself, while Captain Rodgers occupied the pilot house, attending to the duties devolving upon the commanding officer.

On July 6th, Captain Rodgers was detached. He was a noble man, extremely modest, honorable, and brave, having no superior. His detachment was sincerely regretted by all.

During the night of September 6th, the Confederates evacuated Fort Wagner; on the 7th we were ordered to sound and buoy a shoal channel near it and Sumter, in attempting which we grounded. By signal the Admiral was informed of our situation. After dark a tug with anchor and hawser was sent to our assistance. Throughout the night we were engaged in transferring shot to the tug. At high tide all efforts to move the vessel were unavailing, and daylight found us still hard aground, with a falling tide. The tug returned to the outer harbor, while we quietly awaited developments. At 8 A. M. the receding tide exposed our hull, and the enemy discovered we were aground. The batteries of Sullivan's Island opened upon us, expecting to strike our hull. We returned their fire, aiming entirely at Moultrie. The second XV.-inch (a ricochet) disabled a gun, and exploded their magazine, throwing its contents high into the air, making an admirable exhibition; sixteen men were killed and twelve wounded. The signal from the Admiral, "Well done, Weehawken! Don't give up the ship!" was a source of encouragement at this time. The unequal contest was continued for an hour, until relieved by the participation of the other iron-clads, which had been ordered to "cover the Weehawken." They engaged the batteries until the tide had partially submerged our over-

hang, when they withdrew, leaving us in a safe condition. Again, at high tide, we renewed our efforts to float, applying a tackle to the hawser. All available men on board, including firemen, coal passers, and idlers, were pressed into this service, making a large appearance of men on deck, and they drew the enemy's fire once more, but we made no reply. The movements of the men were directed from the turret top, as from there they could be warned to collect under its shelter as the well-aimed shots approached us. Ensign Chadwick saved his life through his agility in throwing himself over the side, holding by one hand and foot, while the ball passed over. The same ball was dodged by the boatswain's mate, who threw himself flat upon deck. One shot struck the turret top, which I escaped by stepping aside, while it passed directly over the spot I had left, breaking a beam of railroad iron into three pieces, and wounded three men who were skulking within the turret. Notwithstanding this iron storm, our labors were successful at high water, and, as we swung outward, the hawser was cut, and three cheers were given; after which we went to quarters and gave Moultrie a parting round as we steamed away, with only one small leak in our hull.

Our life upon the Weehawken was certainly uncomfortable, and at times extremely so, especially while lying in the outer harbor at Charleston; then an easterly wind caused sufficient swell to compel us to close the hatches. This produced foul air and unendurable heat below. A letter written on board at the time says: "Have been confined below eight days; our food, canned meat heated by the furnace fire." Again: "I am writing this with a towel tucked under my chin, to absorb the perspiration that is streaming from my face." The turret top in good weather was a favorite resort for sleeping, even the perforated iron, with blanket and rubber coat, being preferable to the closeness below; and it assumed quite a literary appearance when the signal was made, "Opportunity to send letters," for writing then became the order of the day. It was also resorted to by the officers when off duty, who whiled away the interval in discussing current events, or in watching with binoculars the effect of exploding shells upon the walls of Sumter. The "wedging up" of the turret was a notable incident of life on board; the resounding thud and the resultant vibration could be heard and felt throughout the vessel, and denoted business. It is possible that many are not aware that a monitor's turret is so constructed that while making passages at sea, or lying in friendly quarters, it rests upon its base. When preparing for action it is raised slightly until its weight rests upon the spindle. To accomplish this a wedge, sufficiently strong to support the enormous weight of the turret, is used. This is called "wedging up." As an appropriate summary of "life on board," I will say there was constant employment, physical and mental, for all classes. Confronted as we were by an active enemy, ceaseless vigilance was required. The responsibility vested in commanding officers of our vessels in front of Charleston, was a strain upon the nervous system which is undoubtedly felt to-day by many, and has shortened the lives of others. Officers of all grades were unable to endure these hardships and discomforts, consequently, changes were of frequent occurrence. It must be borne in mind that, through the exigencies of the time, the crew were

for several months pent up on board, and deprived of the liberty allowed them while lying in port. This privation, in connection with their daily labors, will account for the fact that generally there were several men sick in the hospital. Finally, in comparison with the comfortable quarters usually provided the officers and crew on board our naval vessels, those on board of a monitor appear to a disadvantage, and would be desirable only to one willing to sacrifice personal comfort to patriotism.

I was detached on November 4, 1863, after a service of ten months, and about a month later, December 6th, the Weehawken foundered at her old moorings in Charleston Harbor, which loss, in my opinion, was caused by very injudiciously loading her by the head with shot.

Very respectfully, B. W. LORING.

OWEGO, TIOGA CO., N. Y., *November* 27, 1885.

GENTLEMEN :—Your communication of the 17th November is received. The action between the Weehawken and the Atlanta has left a very vivid impression. The guns in the Weehawken's turret were an XI.-inch and a XV.-inch, and were under my command during nearly the whole service of that vessel, as she was sunk thirty days subsequent to my detachment, and my service on board commenced before she was out of the builder's hands. I know of but one shot having been fired that I did not sight. The first captains of the guns pulled the lock-strings at my order "Ready, fire." I never used the sight-vane, which was situated near the port of the XV.-inch gun, but sighted over the XI.-inch as a sight for both. That was preferable for two reasons—one, that I could stand either side of the breech and watch the object to be fired at; the other, that I could stand nearer the engineer who governed the turret machinery, and could thus control his movements more perfectly. Through practice, we were often able to stop the turret upon an exact aim, and the order "Stop, ready, fire," came together. As the object approached the line of sight, by the motion of my hand the engineer gradually slowed to a stop.

The distance was obtained by *estimation*. It was Captain Rodgers' intention to waste no ammunition at long range; therefore, he gave the order to elevate slightly. The order "Open fire" was not given until within *certain*, point-blank range. We used thirty-five pounds of powder, never more, and cored shot (four hundred and fifty pounds, I think), for the XV.-inch gun; and for the XI.-inch, the ordinary charge of powder and solid shot. We exercised daily at the guns, the only previous fighting exercise being at the first attack upon Sumter, April 7, 1863, when the Weehawken led the line of battle, and I had the honor of sighting the first shot at Sumter after its capture by the rebels.

A few details regarding the working of the guns and turret may interest you. While I was upon deck attending to details left undone, in the hurried clearing ship for action, the guns were loaded under the supervision of Lieutenant-Commander Cornwell, and when I entered the turret we were quite near the Atlanta. I had scarcely reached my station when Captain Rodgers gave the order to "open fire." The thickness of metal at the breech of those heavy

guns is so great that the primer frequently lacked force to reach and penetrate the cartridge, consequently, the captain of the gun was provided with a small flask of fine powder to prime with, but was not expected entirely to fill the vent. That is what they did, however. The primers could not be inserted. Without mentioning their error, I was told the primers would not enter. Discovering the cause, I gave orders to cut off the quill close to the wafer. While the captain of the XI.-inch was doing this, the XV.-inch was announced as ready. We were three hundred yards distant from the Atlanta. The shot struck near the forward end of the armored casemate, in the vicinity of two guns' crews, who were prostrated, and many wounded, by the concussion. The iron armor and angling side deflected the shot, which passed over, smashing a hole entirely through her side, nearly large enough to pass a barrel by ending over. Having reloaded the XV.-inch, and maintaining the same elevation, *both* guns were fired. The XV.-inch shot missed (the only one that did miss); the XI.-inch struck the upper edge of the pilot house, throwing fragments of iron upon the heads of the pilots and felling them upon the trap-door, through which entrance was made to the wheel, effectually preventing ingress, and the Atlanta grounded upon the shoal near the edge of which she had been running. While reloading for a third round, the quartermaster reported that a white flag was waving from the Atlanta. Captain Rodgers, being unable to see it, ordered the firing to continue. Another round of two guns was fired (making a total of five shots); both shots took effect, the XV.-inch upon the knuckle, the XI.-inch three or four feet higher, tearing away her heavy port-stopper that was hung upon the outside. The quartermaster again reported a white flag upon the Atlanta, which could now be seen distinctly, and we ceased firing.

The distance was slightly increased between the second and last rounds. I have given you all the information requested regarding the battle, but will add something about our *method* of working the guns and turret. Our fire was rapid for a monitor, and I will explain how it was obtained. During our first fight with Sumter, the service of the guns was torturingly slow, under a return fire that is seldom equaled. (The shot pelted us, and the water near us, which latter was thrown over the turret top, falling down upon us like a rainstorm, compelling the captains of the guns to cover the vents.) The time required to load was between six and seven minutes.

Several days after, I devised that *traveling bar* which you will find in the turrets of to-day; it expedited the loading and lightened the labor. At the same time, I invented a method of indicating to the engineer where to stop the turret that a clear opening might appear on both sides of the turret chamber, and that the powderman and tackleman might know which grating to remove, and also that the powder and shot passers below might know exactly where to stand, ready to hook on when the turret stopped. These men performed their different duties simultaneously, upon an order given by myself immediately after the discharge of a gun. No other sound need be heard save the revolving of the machinery. The turret stopped at the place indicated, the shot and powder whip dropped below at the first appearing of the opening, and the powder would be nearly up to the grating by the time the turret stopped. We never

used the port-stopper, but turned the turret one-quarter away from the object engaged, avoiding the necessity of using the sectional rammer and sponge, thus saving the time required to connect and disconnect them. The indicating method also avoided the outrageous confusion both in and below the turret, in the endeavor to find where the powder and shot were required, and the repeated request to the engineer to turn a "little this way or that" to make a clear opening below. While in battle, all openings upon the deck were securely closed with heavy iron hatches, difficult to open from below; hence, should the vessel come in contact with a torpedo, the readiness with which clear openings could be made to the turret chamber would greatly facilitate the escape of the crew to the outside. Again, having two classes of guns to handle is an element of confusion and delay in the chamber below, through the uncertainty of where the ammunition of each may be needed. This was also remedied.

Another benefit worthy of mention was that I was able to work the XV.-inch gun with only nine men in the turret, shot being hoisted by men in the turret chamber. In the contracted space of the turret we found this of great advantage. The XV.-inch could be served in nearly the same time as the XI.-inch, it being reduced from between six and seven minutes to about two and a half, making the service of our monitor equal to nearly three under the previous conditions. This fact can be verified by referring to the report of Admiral Dahlgren to the Secretary of the Navy : Navy Report, 1863, "Summary of Service of Monitors against Morris Island," etc. Making allowance for the fact that several of the monitors were called into action a greater number of times than the Weehawken, notably the Montauk, Admiral Dahlgren made the Weehawken his flagship, *during action*, early in the operations against Morris Island, and continued to do so during the attacks thereafter, for the reason (as he remarked) that we "fired more rapidly and with less noise and confusion than any other monitor." Chief-Engineer James G. Young, of the machine repair shop at Port Royal (an engineer on the Weehawken at this time), introduced the traveling bar into the other monitors, when placed under his charge for repairs, and, I have understood, claimed the invention. This may not be true, however.

If any portion of this statement is not fully clear to you, I shall be pleased to explain. You will see by the date that I have taken considerable time to complete this communication ; being in poor health, I have been unable to apply myself continuously.

Respectfully yours, B. W. LORING.

OWEGO, TIOGA CO., N. Y., *December* 16, 1885.

GENTLEMEN :—Yours of December 10 is received, and it gives me pleasure to know that you found the account of the service of the Weehawken interesting. It has been equally pleasant to me to recall the stirring incidents of those days, and has not been of the least trouble. I have no objection to its being published, if you think it worthy of that honor, although not written with such expectation.

In regard to the sights and manner of using them, my memory fails me, and I can only give very unsatisfactory information. The XV.-inch was fitted with a trunnion level, but the XI.-inch was not. What it did have I cannot bring to mind. I know that I used the sight bars and level only to obtain the elevation, using the line of metal of the XI.-inch gun for the lateral training (not recommended to an unpracticed eye). In the action with the Atlanta the guns were elevated to 300 yards, and the first round was fired at that distance. The second (two shots) was fired with about the same elevation, but the distance was decreased slightly, perhaps twenty-five yards, causing the shot to strike higher. At the last round the distance was increased to probably 350 yards, which, with the same elevation, caused the shots to strike somewhat lower than either of the others. The cause of the variation in distance is accounted for in the following explanation, and was not intentional. When the Atlanta was discovered approaching from above us, in the indistinctness of early dawn, the Weehawken was heading down to a very strong flood-tide. Her cable was slipped, and she was run down some distance for a wider passage in which to turn, to meet the Atlanta face to face. The channel being narrow increased the strength of the tide; therefore, when our fire opened, at 300 yards, but a short time was required for the tide and the momentum of our vessel, together with the headway of the Atlanta, to sweep us abreast of, and at the last round considerably past, each other; for reversing the engine of one of those clumsy monitors under those circumstances had but little effect towards decreasing headway.

In the attack upon Sumter, April 2, 1863, the distance between the Weehawken and the fort, when fire was opened upon her, I can only imperfectly estimate. It probably was from 800 to 1200 yards; from Moultrie perhaps 1500. The other forts I cannot estimate. While the fire of all the forts was concentrated upon the Weehawken, before the action became general (she being in the lead), judging from the unceasing beating of projectiles upon the turret and hull of the vessel, and in the water alongside, there might have been at least 100 guns engaged against us. During this time there was a sufficient quantity of water thrown over the turret top to endanger wetting the priming—to prevent which the vents were covered—and the occupants of the turret, myself included, were wet, but not seriously, the opposing fire being soon divided among the fleet. You may imagine the pandemonium without, arising from the splashing water, the impact of shot, which broke into fragments as they struck, and spattered an iron hail upon our iron deck.

Our engagements with the forts at Charleston were upon an unruffled water, and point-blank ricochet was my favorite method of shooting. The XV.-inch heavy shot and shell bounded beautifully over the surface of the water. In night-attacks, a much superior sight could be obtained with the eye near the port-hole. I was enabled to do this by lying prone upon the top of the gun, giving the command "Ready—fire!" as I sprang off.

Respectfully yours, B. W. Loring.

U. S. NAVAL INSTITUTE, WASHINGTON BRANCH,

MARCH 11, 1886.

REAR-ADMIRAL S. B. LUCE, U. S. N., in the Chair.

A VIEW OF OUR NAVAL POLICY AND A DISCUSSION OF ITS FACTORS.

BY WM. BAINBRIDGE HOFF, Commander U. S. N.

It has always struck me as very odd that officers of our Navy and members of our maritime communities have not thought more, or at least have not expressed themselves more in the public prints, upon a science which, even at this present time, has a large mass of literature of its own. Men in foreign navies, and tacticians who are not naval, have devoted themselves, year after year, to classifying and arranging the conclusions reached by experiment; and in no branch of this science which I term "tactical," has more satisfaction been reaped than in arriving at decisions in regard to what is needed in the way of vessels for defence. Given a coast, what is required to defend it? Or even given a country, what navy is required to protect it?

The next question, Given a locality, what navy is necessary to subdue it? is more complex, since we very well know that certain forces of vessels will be required for certain localities, and that a navy could not be built to suit each one, and then be put away and labelled, only to be used when such locality was to be acted against. Therefore, for us in this country, this part of the tactical question must be modified so as to stand something like this: A naval defence being provided, what foreign cruising navy is needed to protect each dollar of American capital floating foreign; what naval protection is required to make this coin breed fastest, and what ships are necessary to keep our *personnel* in the highest condition of efficiency? In regard to this last, it may be said right here that the requirements of the modern vessel are such that the commanding officer will have his *overalls* on two days, to one that he will wear his epaulettes.

Coming back to the first question, What is required for the naval defence of a country, we are immediately met face to face with several unpleasant facts, but none more unpleasantly prominent than the fact of the unconscionably long time it takes to put a ship afloat in fighting trim. In old days the great gun was described as a hole with molten iron poured round it; and four months before the lordly frigate sailed on her mission of war, her whole fabric was perhaps sheltering the piping shepherd and his flock on some quiet hillside. This question of time, however, is the worst side of the case, and if three years are now demanded to build a line of battle ship, we have this recompense, that Tactical Science, if we go to her, will tell us exactly what sort of a vessel to build.

Naval Tactics, as I have hinted, has now its laws laid down with more or less precision, and it only awaits the action of the practical student to have them more fully codified. It is the mother science of naval warfare, since it instructs us how to measure a locality for its defence in the same way that a tailor measures us for our clothing. Or, if this is not taking high enough ground, it may be stated that the tactician can write out a prescription for defence in the same manner that a skillful oculist writes a formula for a pair of glasses for his patient's eyes. In each case the elements of weakness form the basis for determining the protection.

I am well aware that I am using the word *tactics* in an unusual sense; still, I venture to give my reasons for differing from the ordinary military definition. For instance, Jomini says that tactics is an *art*, and deals with the proper use of masses—either on the drill ground, away from the enemy, when it is termed *minor* tactics, or in an engagement with the enemy, when it is termed *grand tactics.*

Between military and naval tactics there is, as it were, a perfect identity, and yet a radical difference, as will be seen by the following illustration. A general combines his fighting factors, just before or during a battle, to suit the conditions which will, as far as his insight goes, either compel victory or avert disaster. Thus he places certain guns, or certain squadrons of horse, to cover such-and-such bodies of foot. When he has done this, he has established certain self-supporting *nuclei*—units—which, if they remain intact after the combat begins, are permitted so to remain; if, however, they are destroyed, or the balance is broken up, the combination is perfected by supplying from a reserve the defective arm, whichever it may be—cavalry, artillery, or infantry.

With the naval tactician this same thing occurs. He also marshals his elements—the gun, the ram, and the torpedo; and he marshals them for one purpose alone—to serve in the line of battle in conflict with the enemy. Formerly, when all vessels were alike gun-platforms, with a common arc of fire, and were manœuvred by sails, the admiral could at a late hour begin to distribute his forces and dress his lines for battle precisely the same as if he were a general commanding troops. *Now* the tactical aspect of a war, the absolute fighting of a battle, causes the tactician, in order to be successful or prevent defeat, to see the need of certain combinations, such as gun with torpedo, torpedo with ram, etc., etc. These combinations are, of course, impossible for him to make after the *unit*—the vessel—is constructed, and, therefore, the *time element* enters to such an extent into tactics, when applied to matters naval, that the work of fighting the battle begins in the draughting room or shipyard, where I am going to take the liberty of putting it.

To state it more concisely, tactics begins with the formation of the *unit*. The army tactician can form his unit on the field of battle, while the naval tactician must begin this assemblage in the construction of the ship.

It is all very well to term tactics an *art*, since it is only the *application* of certain conclusions in regard to fighting; but back of it all is the science, which we term Tactical Science, and which I should define as the knowledge of the *requirements* of war for offence and defence; Tactical Art, as the proper employment of the elements of war combined in conformity with the conclusions of tactical science.

The question is naturally asked, How can these tactical measurements be made, which we referred to a few moments ago? The answer lies in the fact that nearly everything entering into the building and fitting out of a ship depends upon the most delicate adjustments and most refined results as regards mechanism. By the study of thinking, practical men, and in the case of our Navy, I am glad to say, by the enlightened work of our Naval Academy graduates, certain instruments of war are made to suit certain conditions. A certain gun is made to do certain work; for instance, some are armor-piercing, and some are designed for lightness and rapidity of fire. A certain hull is planned to stand best on such a coast, for such a purpose; a certain economy of deck space is best adapted to certain classes of vessels; and so on.

These materials being furnished, it is the tactician's province to

assemble them in obedience to the demands of the locality to be defended.

In the same way, in offensive foreign operations, the tactician puts together in the best manner all the factors of war which the specialist places in his hands.

The specialist must deal with questions in his line. If he is an ordnance officer, he must determine how to obtain greater muzzle-speeds with less chamber-strains for his guns. If he is a constructing engineer, he must strive to stow away a horse-power in fewer cubic inches. If he is a naval constructor, he will aim to accomplish the same strength of hull with less weight. What is true of these men is true of all others engaged in furnishing the factors for success of naval vessels in time of war. The tactician must not only put all these together in the best way, but he must draw up rules how they must be used to serve the intended end. It is his business to grow nuts for specialists to crack. He remembers that the question of time enters so largely as a factor in all preparations for warfare, *that everything must be used for its full value.* He must not install an armor-piercing gun in a vessel where it would be the remotest contingency for it to engage an armor-clad. He must keep in view the service upon which a vessel will be employed; whether its field of action is so far off that it will be hard to obtain coal or ammunition, or whether its cruising ground is in a locality where supplies are easily procured. Here will come in the question of sail power, coal space, and size of guns. In regard to this latter, it will be remembered by him that where a five-inch gun will do as well for the work in hand as a six-inch gun, he can carry two five-inch guns where only one six-inch can be taken; and where, with a six-inch gun, say only 500 rounds of ammunition can be stowed, with the smaller gun very much more than that amount can be carried. The tactician will find it especially hard work overcoming the prejudices of those who build our ships, or at least of those who heretofore have built them—men who never went to sea themselves—in regard to this matter of guns. Thirty years ago the gunboat was no more vulnerable than the frigate, and it was good sense to put in the gunboat the largest gun she could carry. Nowadays, we hear people, who should know better, boast that they are designing unarmored vessels to carry batteries of the greatest weight of metal, forgetting that these guns—very costly and made with a purpose—will never be used as intended. What is the sense of driving a tack with a sledge-hammer?

Right here would come in the canon that the defence should equal the offence as nearly as possible. If our guns are of good calibre, and yet are only protected by the paper-shelled side of a ship, they will not have justice done them in a fight, since their crews would be destroyed if it were attempted to employ them at their full value. These guns should at least have their crews protected against the fire of rapid-firing guns.

Again, another canon is that the thinner the protection, the more separated the guns composing the battery must be. This is comparable to separating into lines of skirmishers the ranks of soldiers, which, in days when arms had less precision, rapidity of fire and length of range, stood shoulder to shoulder.

These canons are the conclusions drawn from the experiences of navies—deductions found by assembling the factors of war in ships, and drilling such ships in fleets.

It may be said, too, that they are being continually violated, not only in our service, but in other services. This comes, I conscientiously believe, from a disregard or ignorance of the performances of ships in battle, and the conditions surrounding a contest with an enemy. These can only be learned by a close application to the study of naval tactics, the new seamanship, the naval officer's legitimate calling. The application of this study, which serves as the foundation for building up the great science of naval warfare, is the underlying idea in the establishment of the War College, and it rests with us whether or not this seat of learning succeeds in its endeavors.

In support of my conviction in regard to the tactician being the one to suggest how ships are to be built, I would beg leave to call your attention to a few facts in connection with a vessel now being built for the English Government—one of the few, I believe, where a person skilled in this science has had his views carried out. If I am not misinformed, I can associate the name of an Admiral of the Royal Navy with that of the Renown. Here is a ship of great speed—18½ knots; with double screws and therefore great manœuvring power, fitted for the line of battle, large enough to give a great, crushing blow with her ram; her vitals covered by a deflective deck, her sides belted with armor to resist heavy shot, and with two enormous guns forward, protected with heavy armor, to accentuate a ramming attack. This is common to many ships, but if we had the plans here to look at, it would be noticed that these guns are put in the vertical axis about which the vessel turns; the reason for this being that,

the larger guns are, the slower they will be served, and the fire, to be most valuable, must be most accurate. You will readily see that the nearer the guns are put towards the extremities, the more the steering enters as a marring effect to their precision of fire. To continue our description of the Renown: She has a battery of six-inch guns (note the small size), whose crews are protected from rapid-firing gun projectiles by light-armored sides and traverses. Again, these guns have a greater train aft than forward, which is novel, and would leave their mark on a ship which has just charged past. To this battery may be added a fairly heavy gun firing astern and an adequate secondary battery. See where common sense comes in, in regard to guns! We want weight of fire to supplement the ram—two 110-ton guns; we want rapidity of fire in broadside—comparatively light guns of only six inches calibre. As regards torpedo offence, she is as well supplied as, but no better than, many another ship. Viewed from the standpoint of a seaman, this naval man's ship stands pre-eminent. I do not for one instant say that we should copy her, but I only mention her as a floating tactical argument of the highest and most satisfactory class.

In point of fact, I cannot understand why a country should adopt such a naval policy, which, as far as her finances and the means at hand will permit, causes her to copy the navy of some other nation which leads in this respect. It is for this reason a navy is built without system, one set of legislators wishing to have big ships, and another set striving to carry a measure in favor of small vessels, ignoring completely the precept which forms the basis of good naval policy—that ships, like pegs, should be made to fit certain holes.

The British Navy, for example, is maintained under conditions in no ways applicable to those which surround ours. Because it is vital that Great Britain should have a certain number of armored vessels, it is no reason that we must build ships of like character. I do not say that we do not want armor-clads, but I have reference entirely to a blind following of characteristics and numbers. No two countries could be more unlike tactically. England's navy for defence is like the thread which unites the pearls of some rare chaplet; ours resembles more the setting of a single jewel. Great Britain is spread over everywhere; she must be nourished from outside; and she is moved by any political disturbance in Europe, Asia or Africa. We are concrete, self-feeding, and, from a tactical standpoint, invincible. Perhaps, of all countries, ours is the least difficult to decide what shall constitute its naval defence.

The war question ciphers itself down to this: Given at each point the amount of invested capital assailable by the enemy, what proportion of this amount shall be diverted to furnish a defence? To determine this, our coast would be divided into districts, as is done under the Lighthouse System, each division requiring, possibly, a different class of defence, involving the building of different varieties of ships. As the New York district requires more and better lights on account of its commercial importance, so it will have a larger fleet of vessels and a more elaborate system of defence. To do this would require an enormous increase of the Navy. Not only is it true as regards ships, but also in regard to the very great number of men it would require to man them—many more than are available; and if it were done, our industries might suffer from the withdrawal of skilled labor.

Let us take any four of the great commercial ports which differ hydrographically, and determine what classes of vessels, and the number in each class, are necessary to furnish each of them with the very best defence. All those vessels which are common to each of the harbors should be furnished, built and supported by the General Government, but the special vessels found necessary should be built by the States in whose waters they will act, and be manned by the militia of those States; or if built by the General Government, should still be manned by the State troops. This idea of mine will meet with objection from the very outset, especially, I am afraid, from my naval brethren; but when we remember that these special vessels will be either torpedo vessels or harbor armor-clads, we can see how easily they could be officered and manned by those who follow the water trades about their homes. The Naval Volunteers and the Volunteer Torpedo Corps of Great Britain, organized for her coast defence, will be a safeguard which the whole world will be quick to follow one of these days. The tugboat captain, who knows his waters perfectly, will, in my opinion, in this particular case of commanding harbor-defence ships, be of more value than the naval officer, and will permit this latter to serve his time more strictly at sea.

Under the common-sense rule of employing people in callings with which they are best acquainted, and thereby reaping from their work the greatest return, it would seem to be logical to employ such volunteer bodies where they are undoubtedly familiar, in vessels which they have built, and in which they have been thoroughly drilled. It must be remembered that times are changed; that wars

are a question of days and not of years, though the destruction is as great as formerly. You cannot take a recruit now and make him of value after the beginning of hostilities. His highest value would be found in keeping him in a certain station, in a certain ship, acting in a familiar locality, as I have indicated.

It was my good fortune last summer to make a short trip in a vessel, a double-screw gunboat, the Avon, officered and manned by a body of naval volunteers. There was a naval lieutenant on board, not part of the organization, but who was embarked as "guide, philosopher and friend," and who was never to assume control unless he conceived that Her Majesty's property was in danger. The commander was a merchant; one of the sea officers was a London physician of standing; one of the blue-jackets—he was peeling potatoes when I saw him—was a London barrister with a practice which brought him in $10,000 a year. There was a small leavening of sailors drawn from the Royal Navy among the crew as supernumeraries.

As far as I could see, the work was perfectly performed, the ship being taken into port and anchored in a skillful manner. The crew was finer than most of the crews of naval vessels, since a number of them were educated men, and were serving from enlightened motives. These gentlemen paid their duty to the Crown in this way for six weeks in the year. What a chance for our yachtsmen! How easily this could be done in New York! In one week two regiments could be made web-footed, and the drills could be had on board the Minnesota, or the Government could supply under proper control, as in England, men-of-war, for instance, the Wyoming, at the Naval School during the summer, or two or three monitors. These regiments, or whatever may be found to be the best designation for this force, would be uniformed as are the corresponding grades in the Navy, with some proper, distinguishing mark. This system will not only employ people in time of war on an element to which they are accustomed, but will also be of great service to us in the Navy, the least known of all the servants of the Government, as we can then have something in common with our fellow-citizens. If we can show ourselves worthy of their consideration, we shall be sure to receive it, and if we can prove our superiority in our calling, as our experience *should* enable us to do, they, of all people, will be quickest to acknowledge it, and to give us their admiration.

The system by which the tactician would determine the defence of a locality would be something like this: He would obtain from the

proper sources the distance inland from many points on the seaboard to which an invading army could penetrate without establishing a permanent base. This distance for each point would depend upon how far he could penetrate inside the coast-line before he landed, on the means afforded him to transport his supplies upon landing, and the point at which he would certainly be overcome by the armies resisting invasion. These positions being laid down on the chart, a line is sketched through them called the *inner line.* Now, every water-way lying between this line and the coast is closely scanned. It is decided how many gunboats would do for this river, whether this water could not be cut out by mines, or by a battery on shore, and whether any of the merchant steamers engaged in traffic hereabouts could be utilized for transport or combat. Next, the estuaries are gone through with in the same way : so many torpedo boats, gunboats, or light-draft armored vessels to this sound or that bay, or again, such-and-such vessels to defend this magazine or that strategical point. Then descending to the exposed harbors, the line of forts and shore defences is supplemented by an adequate number of armored and protected vessels, also by torpedo vessels, torpedo boat-hunters, corvettes and rapid-firing gunboats. The coast-line has now been reached, and light-draft lookout vessels are stationed every few miles along it. Here can be utilized small coasting steamers and revenue marine vessels. The tactician now provides for scouring the coast. A line called the *outer line* is drawn through a series of points set off normally from the coast at a distance equal to a twenty-four-hours' run for a fast cruiser. Then, to each harbor of size in the district under consideration, there is allowed a certain number, from two to eight, according to the prominence of the port, of the very best sea-going vessels which will be built for the Navy. These will be large cruisers, both protected and unprotected. They will, in well-disciplined squadrons, never less than four ships together, sweep up and down the coast inside the outer line. Here is where fleet drill of the most rigorous kind comes in, and here, too, is where naval reputations will be made or lost. Having provided for the defence, we get a list of what we want in the way of vessels ; and I am free to confess that in a district which would include a great commercial centre, the number would be very great. Of course, they could not all be supplied at once, and all sorts and conditions of vessels would be needed. *The thing to do would be to build both ways from the coast-line.*

It can be seen that such a system will always work, although the

characteristic features of the vessels would change. Let us adopt this or some other *system*, and, having once done so, for pity's sake, let us stick to it. Congress, the President and the Navy, would know, from year to year, just what would have to be done, and how much would have to be appropriated, making a great saving in time, temper and talk.

Now, having arrived at a system for defence, let us follow the plan by which a foreign cruising, offensive-acting navy should be built. As we have said, this question is much more complex, but is based upon conclusions reached something in this manner: Find out towards what countries our commerce, outside of the great nations of Europe, tends; then arrange each country according to the categories deduced from the following:

First. Its political instability, since a change in its government might bring about complications with our own.

Second. Its commercial relations with this country, derived either from the amount of United States tonnage entering its ports, or the value of consignments of United States produce to American merchants within its borders.

Third. The navy required to subdue it, arrived at by determining the defensive and offensive forces, military and naval, of the country, and its hydrographical and topographical characteristics.

The product of the standings under each of the three categories for each country will give it a war value, and it is for the nation which has the greatest value that our navy should be built to deal with.

Of course, all the sea-going ships built for defence would go to reduce the amount needed for foreign offensive operations.

I well know that all this technicality is intensely stupid to the non-professional listener, but I am very anxious to show him that a navy, to be worth anything, must be built up under some system, and that such system exists, otherwise his money, in common with that which comes from the other taxpayers, will be generally thrown away.

Nor is England free from legislators and others with shipbuilding "fads." Not only in Parliament, but in technical congresses, discussions go on as to whether it is better to build one armored vessel or half a dozen torpedo vessels. The side in favor of the small fry is especially "taking," since the larger vessel costs in pounds what the others cost in shillings, or even in pence. But, somehow or other, these gentlemen seem always to forget that the torpedo boat is worth nothing but against a ship. It cannot carry troops

past batteries, it cannot fight forts, nor can it keep the sea for a long time; and if it costs less, its lifetime is out of all proportion less than that of the great ship. Whether the torpedo can do much harm to a well-bulkheaded ship, remains to be seen. Last summer's experience with the Leander, which vessel tore a great hole in its bottom with a rock, was worth more to the British Navy than the price of half a dozen Leanders, since it showed how badly wounded a vessel could be and yet survive. No torpedo, in my opinion, could have hurt her worse. If torpedo boats are to be used at sea, they must be, as they undoubtedly will, larger, stronger, and armed with rapid-firing guns. The torpedo boats which accompanied the English Particular Service force last summer were so badly used up, battered like old tin pans, leaky and slow, with the frames showing through the plating like the ribs of famished beasts, that they would have been worthless against an enemy. It may, indeed, be said in regard to such boats as these, if an enemy can keep them on the alert for six weeks without his exposing himself, that after that time they need hardly be feared. Shall I go too far if I say that the torpedo-boat outfit furnished to naval powers prior to last year may as well be labelled: "Harmless in a sea-way—unserviceable after two months' employment"?

In conclusion, I would state that the object of this paper is to show the value of these war studies, and that their investigation is our legitimate field for work. It is for such as this that we are educated at the public expense, and it is in this direction that the people expect us to excel. Having no ships, all sorts of scientific *leads* have been followed by naval officers, which speaks well for our desire to be mentally employed; but which employment is foreign to our profession, and which conspires with Congress, where it would seem that heretofore patriotism had been subordinate to party prejudice, to make us of less value as officers, and seamanship or naval tactics, whichever you may term it, a lost art.

DISCUSSION.

The Chairman:—In behalf of the gentlemen present, I beg leave to return thanks to Commander Hoff for the exceedingly interesting and suggestive paper which has just been read. I did not come prepared to take any part in the discussion, but I will express just such thoughts as occurred to me during the reading of the paper. I wish I were better prepared to take part.

I shall not find fault with the use of the word "tactician": I do not care to discuss mere terms. I think, however, that he gives a broader meaning to the word than is generally allowed by modern writers. The lecturer discusses the fundamental principles of naval administration, and the foreign and domestic policy of the National Government; that is to say, he provides for defences—maritime defences, not those on land, but those to supplement the land defences—to be supplied by the floating force, and the question now comes up as to what we are to provide against; what countries are we to expect an attack from? Obviously, there is no object in making any very great preparation for an attack from Switzerland. But what countries are there that we may, in the course of a long experience, expect an attack from, and where will they first strike? What will be their first hostile movement? I think by reasoning in that way we may come down to the force required. From our experience with England, we know that she had two plans of attacking this country—one, a campaign by way of the Lakes; and another by way of our harbors on the Atlantic coast. They once took possession of the waters of the Chesapeake, and we were perfectly powerless to eject them. Reasoning in this way, we may take up the different maritime countries who would undertake to land a force on this coast; but, to cover the entire field of inquiry, it seems to be desirable that the naval administration or the persons who are to act in that capacity should provide against all possible contingencies. So you come in turn to England, France, Germany, Spain, and the rest of them, and say, in case of a conflict with each and any of them, just what is to be done.

The next step would be to divide our coasts into different maritime districts —*arrondissements*—like the French; the Lake frontier, the middle, the Gulf, and the Pacific. It is almost impossible for Spain, in the event of a war, to make any demonstration on our Pacific coast; nor would she be likely to do so on our Eastern coast; so that you narrow the question down to almost one certain locality where a hostile demonstration would be made, and there you are to make your preparation.

I merely offer these few remarks to open the discussion. Now, the thing is to provide against any power having a lodgment in our inland waters—in Long Island Sound, Chesapeake Bay, and Narragansett Bay. A foreign squadron establishing itself in any one of these ports would be very destructive to us. The only thing to do is to supplement our land defences by a floating force. Fortunately, we have here this evening a member of the Fortifications Board, and I would be glad to have him throw some light on this interesting subject.

I believe, myself, that the system of maritime coast defences that we have already inaugurated by means of the monitors is one of the best. The monitor has the advantage of light draught, a necessity imposed by the shallowness of our coasts and harbors, carrying the maximum amount of offensive force with the minimum amount of tonnage.

One of the next questions would be the number of seamen we could muster, counting all the available seamen in this country; to see how many vessels we could properly man. As to that part of the essayist's remarks which call for a volunteer force, I do not believe, in this country, it will be practicable, if desirable. Your barrister friend peeling potatoes, I do not believe is possible in this country. They have tried, and only succeeded in getting volunteers to go down to Fort Hamilton to practise with the artillery. I do not think the people will do it. They will go out and parade in uniform with the young ladies looking at them, because there is something very spirited in that: it is very pleasant. But to go down the seacoast to work those heavy guns—it does not show up well. And you will find very few of them who will be willing to go on board ship, unless the danger is so imminent as to drive them to do it. But I say I think we can bring it down to a fixed point, that we could reason, in the way I have mentioned, the probable enemy we might have, fix upon the enemy, and where he would make his first attack. That is the question; having settled that question, what force must we have to meet him? We must not only have force to meet him, but to crush him. We can be studying out these questions coolly beforehand. So many men and so many guns must be at such a point at such a time. That is one of the problems to solve.

I do not care about terms. I do not think the providing of defences belongs to the tactician. It belongs to the Navy Administrator to administer the affairs of the naval government. An officer said to me to-night that he had never been in the Navy Department, meaning to say that he had not been concerned in its affairs. Nor have I, and I am not prepared to say what is going on in the Navy Department; but, so far as my knowledge goes, I do not know of a single officer who has the duty assigned to him of saying what shall be the first movement of this country on the waters in the event of hostilities. If there is such an officer and such an office, I do not know it, that is all. And when during the *fiasco* created by the Virginius, I know perfectly well that somebody was, so to speak, "at sea," and it would have been better if they had been so literally, instead of figuratively. They did not know what to do, and somebody did then a most disgraceful thing in sinking a coal barge at the head of the dry dock to shut in a possible enemy's ironclad. If that was not an evidence of the weakness of this country as a naval power, nothing was. This country should have said, "Here, we will hurry you through and let you go to sea and meet any power that Spain can put upon the ocean!"

I beg your pardon for my rambling remarks; I should be glad to hear any gentleman on the subject of the paper.

Rear-Admiral SIMPSON, PRESIDENT OF THE INSTITUTE:—To undertake to deal with what we have listened to, properly and elaborately, would require more time than we are likely to give to the matter here. The paper is suggestive, but there is one point to which I wish to address myself, which is denomi-

nated Tactical Science, which, as defined by Commander Hoff, is a subject that we should all accustom our minds to.

I am inclined to think, however, that the tone of his address would lead one to suppose that this tactical science, so-called, has been heretofore entirely neglected. I allude to it as applicable to single ships, and not from the more general and administrative point of view brought into consideration by the remarks of the Chairman—I mean the study of combining in one ship the features particularly required by her for the specific duty for which she may be assigned; that, I understand, is the tactical science, so-called, as applied to a ship.

Now, that is a matter that, in our new ships, has been very deliberately thought out, and the great study in designing and planning their general features has been this very point. The understanding seems to be accepted by the country and by Congress that different classes of ships are required for special duties differing in their character; that as these duties differ, so must the characteristics of the ships differ, and this study, called by the speaker tactical science, is being carried on now by those who have charge of the work on these vessels. For example, an unarmored cruiser that is intended to keep the sea for a long time must have a large coal endurance and high speed; she must yield in her gun power, and she has no protection except that derived from her system of construction; she has no armor. The coast-defence vessel must be as strong as possible in offence and defence, her speed must be reduced and her coal endurance limited, and the space for all consumable articles must be diminished as much as possible; that, I understand, comes under the head of tactical science as the term is used by the speaker.

Now, the classes of vessels proposed by Commander Hoff seem to be all very much provided for by the propositions already advanced; the unarmored cruisers and armored cruisers are being built, and are under consideration, and the Fortifications Board has given us designs in accordance with this tactical science for vessels for the defence of the coast, and for that of interior waters; thus, it seems that the call for suitable vessels for specific purposes is pretty well answered now in theory; it remains only to embody these ideas in practical form, which will demonstrate that this science has been called into service. The torpedo boats that have been recommended are available for all purposes of inland work alluded to by Commander Hoff, so I think that most of his suggestions are being now acted upon.

My remarks are intended to express my opinion that we should not be accused of having neglected this science up to this time. I think, rather, that we have adopted it.

Commander Hoff:—The remarks of Admiral Simpson call me to a sense that perhaps my remarks might be construed in that way. I did not so intend. As to what has been done in the way of building our new vessels, I think that the mere fact that the good which has been done in this direction is what attracted my attention to the fact that if the whole Navy would wake up to appreciate what those who are building our vessels are doing, it might tend to hold up the hands of those who are rehabilitating our Navy in a way, to say the least, that is making great strides in the proper direction. I think that if

the whole Navy were alive to the importance of the work, and would send in the results of their study and observation, the Board which is building our vessels would be greatly assisted thereby. From the time the first vessel was laid down under the last Board (I mean the vessels which they are now finishing), I think the members will say, as they went along step by step, they were obliged to learn, as well as put in practice, what they already knew.

Now, in regard to these new vessels, it seems to me that it would be well to install some smaller guns by the substitution of V.- for VI.-inch guns.

I think all these points in the study of tactical science show how much there is to it; and as for the officers who have devoted so much time and labor delving into the science of modern shipbuilding, and have given us the first modern thing that we can call our own, I am certain the greatest credit is due; and as to assembling the factors of war in what I call a tactical, scientific way, I consider myself to be only a novice.

The Chairman:—Yes, that is it; one set of men giving entire attention and study to one branch, and another set of men to the study of another. It is not every set of officers that can devote their time and attention to every study: it must be divided among them all. It is by bringing together the work of many that we achieve great results; each man working in the line of his own specialty.

Commodore SCHLEY:—The paper of Commander Hoff is extremely interesting and suggestive. As a plea for more earnest study of the policy of defensive protection, it commends itself to my judgment as an excellent outline of the direction into which our attention should tend. In case of defence, the plan of districting the country as indicated by Admiral Luce would unquestionably be resorted to; that district to be most carefully guarded as its commercial interests would invite attack. Commander Hoff has indicated a type of ships and a system of attack and defence that would embrace many peculiar vessels.

It has been stated by eminent authority that the fighting officer is best qualified to know what type of vessels are most needed for offensive and defensive purposes in war, and that the most successful constructing officer is he who can so mould his ship and accommodate her to the conditions set forth by the fighting officer as necessary.

In this view, therefore, there is unlimited scope for the mentally active and progressive of our service. Papers of the character under discussion must tend to certain good results if looked at in the right spirit, or if discussed with the sober desire to add to our information all that most concerns the public protection.

The time has passed when we could improvise our defence from the declaration of war until the arrival of hostile fleets upon our coasts. The vaunted ocean barrier of former days has been annihilated by the swift machines of to-day, so that future wars between nations will be almost as that between man and man: the insult will be followed by the blow. Our special province, then, is best fulfilled by giving our most earnest study and thought to the considera-

tion of just such things as Commander Hoff has so admirably presented to-night. I think it would be safe to say that if we as a body will give ourselves more to this intricate concern of war, and to all that may be needed to make it most destructive to our country's enemies, our advice and opinions will gain respect everywhere. We shall at least be better equipped when the time shall come to improvise hastily the defence of ports, or of coasts, than if we waited for the emergency before deciding what was most needed.

One point of this excellent paper deserves attention, if not criticism; I mean where Commander Hoff speaks of the special vessels that are found necessary in his system, and his declaration that these should be built by the States and manned by its watermen. It must be admitted that all naval vessels to-day are to a greater extent machines than ever before. Our profession has grown to one in which nobody not an expert could have any place. The various implements used on board ships of war all require most careful training to their uses: our delicate machine guns; our intricate torpedo fittings; our wonderful search lights; our elaborate electric-lighting connections; our new and expensive guns, with the masses of delicate machinery for working them,—all would seem to favor the idea of special training. It certainly combats the notion that men could be picked up about our seaports who could acquire this necessary knowledge of these new things in a few days. It certainly argues for permanent establishments, rather than for those thus irregularly maintained as Commander Hoff's paper suggests. As the scope widens, and as so many of the newer sciences are applied as destructive agencies in the work of the new war ship, there appears to me less and less chance of usefulness for the man who is not trained to the service requirements. The same need which is so apparent for the officer is in like degree required for the man of our Navy.

This view of that part of his paper would appear to throw out some objection to Commander Hoff's idea. Perhaps he will agree with me that those States which maintain no skillfully trained officers, could hardly be expected to depend upon their tugboat captains for defence against the offensive fighting power of such machines as would be brought against us. Right here I would say that the multiplication of machine guns on naval war ships makes it certain that the destruction of life will be greater than ever before. This emphasizes the need that all officers of war ships should be eligible to command. This would lead to similar education and to the obliteration of the present corps system of navies.

If we could organize in this country such a system of volunteer organization for coast defence as England has, there would be no doubt of its utility in time of war. But there is this in the way: here every one looks upon the military power and upon military service with some dread; and upon peace as in some way an assured thing. The public defence is looked upon as a thing that will take care of itself, or, at all events, when it is forced upon the public attention, means will be adopted to secure it. In England this is different: people there are impressed, first, with the national greatness, and second, with the national safety. There yet live among the English people the inherited traditions of invasion and what they meant in the olden time. It is these things which make possible those things which we cannot dream of here.

I thank the gentlemen of the Institute for the opportunity to discuss Commander Hoff 's very instructive and interesting paper upon so interesting a matter as the policy of our public defence.

Commander GOODRICH:—There is one point in the remarks of the Chairman which I think should be corrected, for the credit of the volunteer force at Fort Hamilton. I have heard that the reason why the exercises at Fort Hamilton were not carried out to a greater extent was because they did not receive proper encouragement from the Bureau having charge of the matter at the War Department; but that the militia from New York themselves would have been very glad to continue them. For this reason, I do not think the plan of getting up a volunteer organization so hopeless as has been suggested. I am, however, not prepared to accept the lecturer's idea without modification.

There is another thing which indicates to my mind that, in any plan or scheme by which the Navy will be rehabilitated, Commander Hoff is right in insisting that the most important thing is to lay down a plan and then to follow it. We know the position which the French occupy to-day. The French Navy in its present state is certainly a very good second, if not coming in for the first place among the navies of the world, because the French laid down a plan in 1872, and have followed it faithfully ever since.

I think that Commander Hoff will call for too many vessels by his scheme. I shall be glad if we succeed in getting them all; but if we can get a few vessels to cover the most important of our harbors, and particularly Long Island Sound, the Chesapeake, and Gardner's Bay, we shall do well. I say, without hesitation, that in my opinion Gardner's Bay, in case of a foreign invasion, would be the weakest position for us and the strongest for our antagonist. I think Gardner's Bay should be occupied with a navy immediately on the outbreak of hostilities, and also, of course, the mouth of the Chesapeake, because we have already suffered on several occasions by the presence of hostile vessels on those waters. I think in protecting the principal commercial points, Chesapeake Bay and Long Island Sound, we will have done as much as we can well expect with the money we shall have at our disposal; even that will give us a comparatively small navy for coast defence.

But granted that we shall have the individual vessels going to make up a fleet, it seems that we are very lacking in exactly this study which Commander Hoff has pointed out as being so valuable. If war were to break out to-morrow with any European power, I do not know whether there is any person in the Navy Department who could say at once what is the proper thing to be done.

It seems as though we should have to take up that subject with great care, and make up our minds what to do with the means at our disposal, so that we should know immediately, without doing a great deal of thinking, just what to do at the very first approach of trouble. And, in general terms, I think that while we may not all of us agree with Commander Hoff's solution of the matter, we cannot help feeling that he has laid great stress upon a want in the service which is becoming felt; and if the suggestions he has made are carried out, not necessarily to the letter, but in the spirit, the service will be greatly benefited.

Assistant Naval Constructor Bowles :—In considering this paper, my mind at once directs itself to the things that I meet with in actual work, and so far I have felt very much the lack of fixed principles to follow in assembling the various parts of the ship into one design.

There is one canon, as it is called in this paper, concerning which I should like to ask the lecturer a few questions. It is, that "the defence should equal the offence as nearly as possible"; and I should like to ask the lecturer if he is aware that if they were carried out, it would rule out every modern protected cruiser that has been or is being built? And that if it be true, it must be that a most outrageous fault is committed in placing the X-inch guns on the Esmeralda or any of Armstrong's last cruisers? In fact, it would reduce the armament of the Chicago to Gatling guns. I should like to ask if, in connection with the facts from which this canon is deduced, due weight has been assigned to the mine power of projectiles, or if the penetrative power only has been considered? Another canon is, that "the thinner the protection, the more separated the guns composing the battery must be." I should like very much to elicit from the lecturer a definite example of what is meant.

And with regard to the use of the torpedo boats and their value in the service. It seems to me that the importance of the experience derived from the manœuvres of the English fleet has been exaggerated, and that the reports, as far as we have them, show that the French are much more skillful in the use of torpedo boats than the English, and regard them as of the highest importance, and that in experience the torpedo boat has proved exceedingly satisfactory.

Commander Hoff :—With regard to the discussion of the first canon, that the offence and defence should be as near alike as possible, it perhaps would best be shown in this way: The broadside battery of the Chicago is the same nearly as the broadside battery of the Renown—that is to say, it is composed of VI-inch guns. Well, if it is not the same, take two vessels—take a large Chicago, with eight VI-inch guns on a side, and take the Renown, which has about that number; you would think that one VI-inch gun should be equal to another VI-inch gun. But one battery would be protected by a side which is easily penetrated by rapid-firing guns, while the other is protected by a side which is not penetrable to rapid-firing guns. In my opinion, the other vessel, the Renown, say, would fulfil more nearly the thing to be striven for than would the Chicago. You cannot do any better than thin sides sometimes, because there are a thousand and one questions modifying the thickness of the ship's side; and, therefore, I only say that the Chicago's side is not as good as the Renown's side. The one has a VI-inch gun installed better than the other. However, there may be sufficient good points in this ship to afford the violation of this canon. A change from VI-inch to V-inch in the Boston would give us the disposition of armor to resist secondary fire, represented by steel plate one and a half inches thick, six feet by one hundred feet. In my opinion, the change should be made at once.

In regard to the canon, the thinner the sides are, the more separated the battery would be; we cannot always rely on one vessel always fighting one

other vessel, and it must be remembered that gun shields only protect in the direction in which the guns are pointed. Take a vessel where all the guns are in the same compartment, as in the Boston or Atlanta: there is no separating one gun's crew from another. They are a mass of human beings kept in a box just thick enough for rapid-firing guns to kill them all. If some of those guns had been aft and some forward, then there would be two *nuclei* instead of one unit. The enemy's secondary firing would then have to be distributed over a greater space, and the slaughter would be less severe in consequence. A rapid-firing gun which is churning out projectiles would be less likely to kill where its fire is divided between two points. Now, the canon goes a great deal further. I have, say, two V-inch guns, which I am endeavoring to overcome an enemy's vessel with. If I can put one V-inch gun in one ship and one in another, and make these two vessels keep a certain distance apart, and manoeuvre together, I could do a great deal better than if the guns were together in the same ship, since I break up in the greatest degree the force of the adversary's fire.

Now, in regard to torpedo boats, I can only say, from what I saw of those which returned from the Particular Service Squadron last summer, in England, and that I went through, that all of them were battered and shaken up. In some the engines looked as if they had been up the hatch and back again. I should think that none of them could make more than nine or ten knots an hour. The French have not had the same experience; I cannot compare one with the other simply because the conditions by which I judge one service are not applicable to the other.

I was told by a Russian navy officer, Aide-de-Camp to the Minister of Marine, that in Russia they keep a record of their boats to determine which are the best, as they have been very large buyers of them in all European markets. And it was determined that the English boats are not so well built, and compared in no way, he said, with the French boats, and that the French boats were very much superior in the question of maintaining steam pressure, and as regards the performance and economy of their engines and their stability at sea. It is but fair to say, however, that relations between Russia and Great Britain were very much strained at the time of this conversation.

Assistant Naval Constructor BOWLES:—Mr. Chairman, the lecturer has brought out exactly the point I wished to make—namely, that the opinions expressed in regard to the English torpedo boats should be as to faults in their design or construction, and should not approach a condemnation of the value of torpedo boats in general, which is the impression I derived from the lecture.

Admiral SIMPSON:—I move, Mr. Chairman, that the thanks of the meeting be extended to the essayist for his extremely valuable and interesting paper.

The motion was carried, and the meeting then adjourned *sine die*.

U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

MARCH 17, 1886.

COMMANDER P. F. HARRINGTON, U. S. N., in the Chair.

BATTLE TACTICS: THE VALUE OF CONCENTRATION.

By COMMANDER H. C. TAYLOR, U. S. N.

In presenting some views concerning the principles of naval tactics, it may be well to say beforehand that these views are in some respects contrary to the general sentiment of naval officers. Some accepted axioms—such as the great importance and value of large ships, large guns, armor, high speeds—are in some measure dissented from; and the ideas generally are not in line with what is known as modern naval thought, as exampled in the development of the present European navies. I am glad to place these views before the Naval Institute, a body so intelligent and so capable of deciding how far these opinions depart from approved custom, and to what extent they should be considered revolutionary or injurious.

The methods I suggest, however, are meant to lead to a most conservative end, concentration; and in making that principle my text and urging its importance, I am only stepping humbly in the footprints of the centuries. Cæsar and Napoleon, Themistocles and Nelson, have recognized it as the essence of victory; have known how so to manage the details of their organizations, the qualities of their individual ships or regiments, the energies of their lieutenants, as to obtain that concentration, so difficult to reach, yet, once attained, so fruitful in victories. Nor does any one of the present age deny in words the value of concentration—assuredly not any naval officers of the present education and experience—but many of us, impressed by the wonderful advance of ingenious mechanisms in these later years, and separated by so long a period from the example of great naval wars, have allowed many minor questions to come between our thoughts and the greater principles of warfare. Concentration has been at times advocated. Solid squares, groups, triangles, have been suggested—for the most part casually, however, and as a minor detail—and at one time, in an able paper by Lieutenant Mason, read before

this Institute in 1876, concentration was effectively urged, and the use recommended of hollow squares with reserves inside, a formation approaching closely the compact orders described in this paper. Such efforts, such suggestions, have been rare, however, and have provoked but a faint attention among modern navies, as of something important and true, but as not specially affecting them; and thus we continue to prepare war ships to be powerful singly, but with little reference to their availability as units of a great and effective mass.

Nelson knew he must concentrate to win; but how was he *able* to concentrate with such brilliant success? Principally because the English builders had built good ships for their navy, similar ships, ships whose build contemplated, first of all, working together, close together—because the Howes and St. Vincents, who came before him, had, through much hard work, trained those ships to work in fleets close together. Thus, when the master mind appeared, grasping the soul of a warlike crisis and commanding effective concentration, the response was instant. Nor were the master's energies wearied and his genius wasted in the long and tedious preparation of ill-assorted fleets and untrained men and officers. We may not all be Howes and St. Vincents, but we may all do our part toward preparing our fleet for that day of our country's need when a Farragut or a Nelson shall demand that trained activity and readiness in ships and crews which is needed for concentration and resulting victory.

What, then, is the object of my paper? Not to prove that concentration is important. That fact is fully recognized, though little acted upon. My object is to urge that it be not only casually acknowledged, but that in every detail of our naval preparation it be kept in view as of prime and critical importance. And I will be doing my small part if I emphasize in this paper the value of concentration in tactics, in the actual engagement; leaving aside for the present the strategic combinations of long-continued operations afloat or ashore. It is concentration in the battle, therefore, rather than in the campaign, which I shall now consider.

What method of tactics will best lend itself to effective concentration—to the massing of our fleet upon a portion of the enemy's fleet? In approaching this question, we must consider what formation will be brought against us. The battle-ships of European navies to-day are of such a character as to make it probable that their formation for attack or defence will be the reverse of a close or solid forma-

tion, that it will be an elongated line, single or double, or a number of detached groups in line or echelon. To approach such a line with our own vessels compactly massed and retaining that compactness during preliminary manœuvring, would ensure the ability of striking the enemy—after preliminary feints—at such portion of his formation as might seem expedient. If we add to this the ability to disengage our ships from this close group and to deploy them, when closing with the enemy, it would seem that we have attained the principal conditions essential to success. Such formation should be of the most simple character. The confusion of battle and the many difficulties of wind and sea make simplicity imperative. For the same reasons, this formation should, through constant use, be familiarly known to the fleet, an order in which they would quickly and naturally gather in a time of confusion or when signals are obscured.

The plan I have to suggest for consideration is the massing of the fleet or squadron in a solid square, or as nearly that as the number of vessels may permit—four ships forming a solid square with a side of two ships (Fig. 1); the solid square of nine ships having a side of three ships (Fig. 2); of sixteen, a side of four (Fig. 3),

Fig. 1. Square of Four.

Fig. 2. Square of Nine, one inside.

Commander-in-chief.

Divisional Commander.

Enemy.

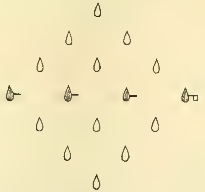


Fig. 3. Square of Sixteen, four inside.

and going on to larger squares, if desirable. The solid square of four ships would have all its ships outside; that of nine would have eight outside; of sixteen, twelve outside, while it may be observed that the number of inside ships in any square equals the whole number of ships in a square whose side numbers two less ships than the side of the square considered. Before discussing some of the features of this formation, it will be well to say that it is the value of concentration in general that I wish to urge, and not this particular form of concentration. The solid and the hollow squares, as two forms of the "naval square," have been occasionally discussed, and the latest authority on the subject, Commander Bainbridge-Hoff, assigns the name of "naval square" to the solid square alone. Many forms of attaining concentration have been at different times suggested. At present, I believe the solid square (or naval square closed in mass) to be the order which, with our improved modes of propulsion and steering, offers the greatest manoeuvring effectiveness, and I shall use it as a text from which to preach the value of close formations and the importance of incessant sea drilling to make such tactics possible. The natural divisions of a fleet in such an order would be the columns which when closed in mass form the square, or the lines which divide the square at right angles to the columns. The flagships of the Admiral and his Commodores should be on a diagonal of the square, in order that whichever way the Admiral shall divide his fleet, each division may always have a divisional commander.

The fleet being in *column of divisions in close order*, the Admiral would simply signal the divisions to *close in mass* (Fig. 4), and the

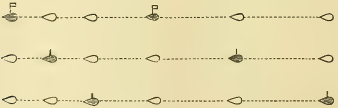


Fig. 4. "Fleet close in mass"—"Van division slow."

closing would continue until distances ahead and astern were equal to distances abreast.

The fleet being in *columns of vessels abreast by divisions in close order*, the Admiral would signal the divisions to *close in mass* by

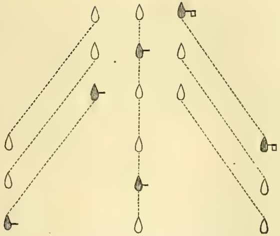


Fig. 5. "Fleet close in mass"—"Centre div. slow"—"Van and rear oblique."

obliquing upon a designated division (Fig. 5), and the closing would continue until distances abreast should be equal to distances ahead and astern.

The fleet in *column of vessels*, van division leading, the Admiral may signal the fleet to *form in mass upon the van division* (Fig. 6), that division slowing to steerage-way, and the remaining divisions obliquing into position at full speed; or he may designate the second division for

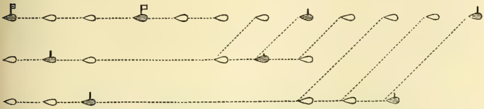


Fig. 6. "Fleet close in mass"—"Van division slow"—"Centre and rear left oblique."

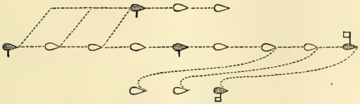


Fig. 7. "Fleet close in mass"—"Centre slow"—"Van to right rear"—"Rear left oblique."

the fleet to close upon, that division slowing, the vessels of van division turning together and obliquing to the rear, and the remaining divisions obliquing at full speed into position (Fig. 7); or if an enemy is discovered ahead and close aboard, the rear division may be designated, and the remainder of fleet, turning together (Fig. 8), will oblique at full speed to the rear into position. Similar principles would govern the fleet when in line, the division designated slowing or keeping full

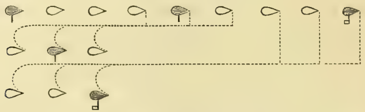


Fig. 8. "Fleet close in mass"—"Rear slow"—"Van and centre to right rear."

speed, according to its position in the square, and the remainder of the fleet moving into position in front or rear of it. It must be thoroughly understood by the fleet that the relative positions of the divisions and of the vessels will always be the same in the solid square, in order that they may drop readily into accustomed positions made familiar to them from long habit; and they must in time of war cruise almost constantly in this order, by day and by night, in good and bad weather, so that when expecting to meet an enemy they may keep in that order and avoid the possible delay of gathering into the square formation from a long and perhaps scattered column line or echelon.

In forming the square, therefore, after thorough drilling of the fleet, the Admiral, in addition to the simple signal to "*Form Square on Division designated*," would only need to give the compass signals to indicate the bearings of the lines of the square. The compass directions of the diagonal line of flagships and of the divisional lines will be sufficient, the diagonal's direction being made the principal indication in the signal. The signal, "*On Van Division Form Square, NE. Division Lines East*" (Fig. 9), will inform the fleet that the Admiral's flag is to bear northeast from the divisional commander's, and that the lines of the divisions will be east and west. The signal, "*On Van Division Form Square, NE., Division Lines North*" (Fig. 10), would inform the fleet that the Admiral's flag is to bear NE. from the divi-

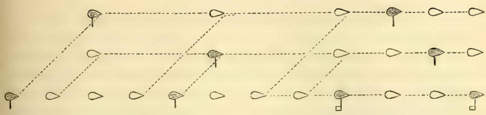


Fig. 9. "On van division form square NE"—"Division Lines East"—Centre and rear "Forward into line left oblique."

Van Commodore signals—"Forward into line left oblique" then "Slow."

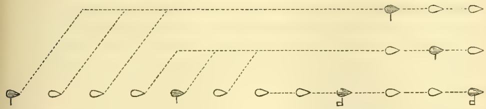


Fig. 10. "On van division form square NE"—"Division lines North."

Van Commodore signals—"Slow": Centre and Rear Commodores—"NW" then "North."

sional flags, and the lines of divisions will be north and south. It will be needless further to describe methods of forming the square: the simple principles of tactics will apply in all cases, with but slight modifications, both in forming square and in returning from it to other orders of steaming; but I will repeat that when expecting to meet an enemy, the fleet should keep in this compact order day and night.

No manœuvring is contemplated while in the "square" formation, except changes of course, and those are to be only the simultaneous change of direction of each vessel of the fleet. There will be no turning of head of column after the signal to "form square" is executed: the only signals will be "*Fleet SW.*, 10 *knots*," "*Fleet ENE.*, 5 *knots*" and similar signals to indicate direction and speed. Even these simple changes of course, you will say, will be difficult for vessels massed in such close order and moving at high speed—nor do I question the difficulty. Ships of great handiness and exactly alike must be built to ensure a homogeneous fleet, and officers and men must be drilled to the last point to make it possible—and even then it will be difficult; but I do not doubt that victory will be with that navy which meets and overcomes such difficulties, and which, by providing this or some similar battle formation for its fleet, shall

ensure the great principle of concentration of force being thoroughly worked out.

I propose, as before said, that the fleet shall habitually remain in this order when expecting to sight the enemy; that once sighted, whether the enemy advances, or remains quiet awaiting the attack, our fleet *shall advance upon it.* If the enemy were in line, the solid square would direct itself, perhaps, toward its centre, steering south, we will say. Approaching closer, the Admiral may signal, "*Fleet SE.*" (Fig. 11), when each ship of the square, consisting probably of nine or sixteen ships, changes course simultaneously to SE., without change in order or bearing—somewhat (if thoroughly drilled) as a school of fish, moved by some common impulse, swerves to right or left without derangement or disorder. Approaching still closer, the enemy's fire becoming hot, and his reserves perhaps

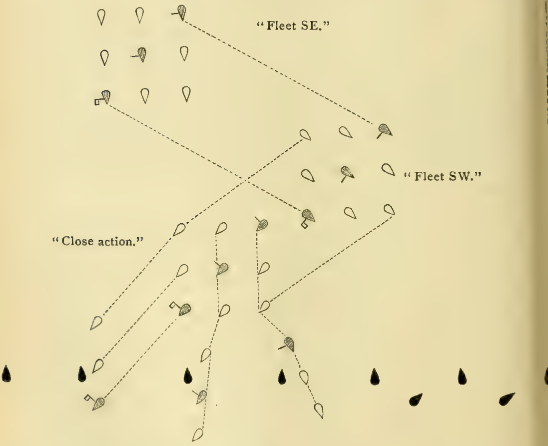


FIG. 11.

hastening to reinforce the threatened eastern division, the Admiral may signal, "*Fleet SW.*," and strike, finally, the enemy's western division. As he closes with the enemy, some deployment becomes necessary, and is simple in execution. The Admiral may signal his eastern division, "*Division South*," the cèntre division or divisions "*Division SSW.*," and the western division "*Division SW.*" This divergence, or a greater, if desired, will cause the divisions to reach the enemy's line with space enough for their effective fighting.

It is, however, probable that the details of such deployment would be governed by a permanent arrangement, preconcerted between the chief and his subordinates, the proper moment for deployment or separation of divisions being indicated by the flagship's signal to "*close with the enemy*." The Admiral would also, at this time or before, inform his Commodores, by a simple signal agreed upon beforehand, whether he intended them to bring their divisions alongside of the enemy and fight it out, or whether, preserving their divisional close order, they should pierce and pass through the enemy's line and reform to some extent on the other side. In this latter case, the simplicity of this formation and the fleet's entire familiarity with it become most valuable. Upon emerging from the smoke on the other side, the vessels—such as got through—would gather quickly into their accustomed battle order, ready at the Admiral's signal to return to their original point of attack, or, if his judgment should so decide, to throw themselves upon some other point of the line.

I think this second formation is not likely to occur, though possible. The old style of delivering broadsides and passing on would permit it, but the ramming inevitable in present fleet fighting must cause delays and confusion. Thus, though many advantages would come to the fleet capable of piercing an enemy's line and reforming instantly on the other side, it should not occupy our minds too largely; nor should any plan occupy us seriously which treats of signals, alignment, formations, *after* close battle is joined; once in hot action, it is not likely that tactics will much avail: bravery and skill and the nautical habit, with a fixed resolve not to surrender, will principally decide the day, when hostile ships once get alongside of each other.

If the enemy is in column heading toward you, which is unlikely, except, perhaps, if surprised by sudden fog-lifting, the square falls at once upon the head of the column, two divisions (say six ships) doubling upon three or four of the enemy's leading vessels, while

the third division, passing farther down the column, takes up the work of delaying the approach of the enemy's centre and rear ships, advancing to assist their van division (Fig. 12). Similar tactics would

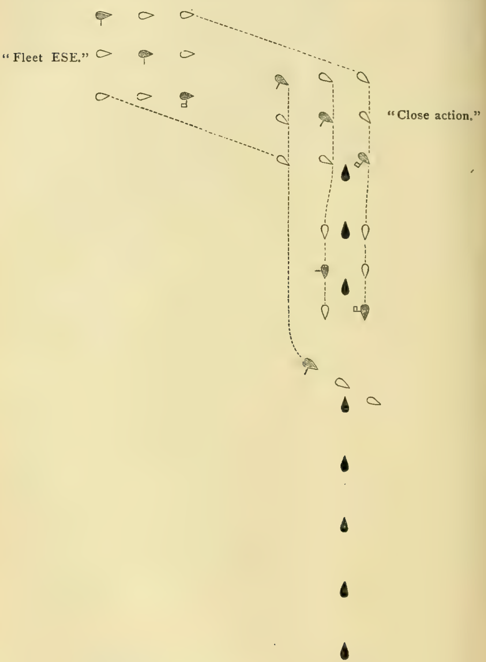


FIG. 12.

rule if the rear of the enemy's column were the nearer; while, if discovered in any detached or scattering order, our compact formation would show its greatest effectiveness.

An advantage of this "square" order, and of providing for its remaining unchanged, is that preconcerted plans can be made with some assurance that they will not be interrupted by the many accidents possible in actual practice. An Admiral, assured by incessant drills that his fleet can maintain this order, may clearly indicate to his officers his probable method of giving battle. He may thus say beforehand: "When, after possible changes of course to deceive the enemy, we finally strike his line of battle, which will in all cases be indicated by my signalling 'close action' to the fleet, the two divisions nearest to that wing of the enemy which we have struck will fight that wing, without further orders. The remaining division, without further orders, will engage nearer the centre of the enemy's line, and will delay—at the cost of all its ships if necessary—the approach of the other wing. Should we happen upon the van or rear of the enemy in column, the same movements will be executed at the final signal for 'close action.' The two divisions happening to be nearer the enemy as we approach will fight the enemy's extreme vessels, and the remaining division, passing rapidly along their line or column, will throw itself in the way of their centre and other wing."

I recur again to the fact that the solid square of four ships has no inner ship whose fire is lost; that the square of nine ships has only one; that of sixteen has four; of twenty-five, nine; of thirty-six, sixteen; of forty-nine, twenty-five. In other words, over one-half the total number are inside ships in a square of forty-nine, while the sixteen-ship square has but one-quarter inside, and nine ships have but one-ninth of their total number inside. These figures are significant, and indicate that our squares must not be too large; for with the loss of fire come other disadvantages, such as the confusion possible in a large mass from the disabling of one or more inside ships. As well as one may judge without that actual practice so lamentably wanting in our service to-day, twenty-five ships will be the greatest number we can place in this close formation, and much skill in handling will be needed even for this. It might be found expedient to divide such a fleet into two squares of sixteen and nine, separated by a convenient distance for support of each other.

The solid square is for offensive purpose only. I am far from claiming for it any defensive value. It is by no means a forma-

tion in which to await an enemy's approach or attack. The evils of closely massing vessels for defence are clearly shown in the case of that fleet, in the galley period, whose Admiral, perhaps lost in admiration of the Grecian phalanx on shore, closed his vessels in a compact mass to receive an attack of a hostile fleet. The enemy encircling the group and approaching closer as they steered around it, pressed back the outer galleys and so crowded the already compact mass as to cause collisions and loss of oars among them, and finally produced such confusion inside the group that the fight was lost before the attacking fleet had made its first charge. But here let me draw your attention to the significant fact of how rarely *any defensive* formation has been successful—how almost invariably victory lies with the attacking fleet. Whether at Trafalgar, where the enemy under way received the English in a half-moon line of battle, concentrating a withering fire upon the heads of Nelson's advancing columns; whether, as at Aboukir, the fleet at anchor, sheltered by shoals, its wings protected by land batteries, received the English, approaching in single column, and obliged to thread their way with tedious caution through a dangerous channel, while exposed to the fire of land batteries and of the broadsides of the fleet—whether there or elsewhere, no matter how certain the precautions of defence appeared to be, the resolute attack has, with few exceptions, overwhelmed the fleet acting on the defensive. I would say, therefore, that I can imagine no plan so effectual for defence as an active offence, and for that offence or attack I know of nothing better than the solid square.

A fair objection to this order is that the inner ships cannot deliver an efficient fire upon the enemy, as they are hemmed in by those outside. This defect is less than it appears, for the order is to be maintained only until close action is joined, when deployment follows, and the columns of the square diverge, and each ship takes room for fighting.

Another and more forcible objection can be made—namely, that the fleet massed thus closely offers a large target to the enemy's guns when within even a long range. I do not see that this defect can be remedied. No formation is perfect. Boldness of attack indicates risks to be run: where no danger is, no boldness can be. It is well, however, to note it as a valid objection, while at the same time we may expect its effects to be much lessened by the wild firing of the best trained gunners in a seaway. The guns also which we may

expect to encounter are of great size and few in number. It required at Alexandria from fifteen to twenty minutes for each fire of the larger guns of the English fleet, and circumstances were there eminently favorable—smooth water, choice of position, a trained and gallant *personnel*, and a feeble enemy. Substitute for these conditions a fresh breeze and rough sea, an ordinary line of battle, a compact fleet threatening under swift headway first one and then another point of their line. Under such circumstances as these, we may, perhaps, justly reduce our estimate of probable damage done by the guns of a European fleet in the manœuvring preliminary to closing. And here permit me to record my settled conviction that closing must take place—that great naval battles will never be decided at long range. Single ships may fight at long range; light skirmish vessels may exchange shots at a distance; but a great battle of fleets, such a one as decides great wars, must, in the nature of things, end in close action. Whichever fleet shall find itself worsted at long range *must* close, or its Admiral forgets why he was sent afloat; and if he closes, his opponent must accept close battle or—run away. Officers of great intelligence have stated to me, as a practicable scheme, that a fleet possessing greater speed and greater gun range than an enemy might steam away from it, and, by making a running fight of it, in time destroy or cripple the pursuer. Truly, this is a pleasing picture. Gentlemen who know the sea can figure for themselves the amount of damage which the stern guns of a fleet in a seaway would probably inflict upon an enemy's fleet, miles away, and in hot pursuit. One of the runaways gets a hot journal, perhaps, and before signals can be made and read is overtaken by the concentrated fire of the enemy rapidly advancing. And if no such accident happens, what is it that the pursued Admiral is doing? He is being chased from some station presumably of importance, and which he has been sent to hold, or of which he is to dispossess the enemy.

Another form of error may be noted in the suggestion of Signor Brin; the eminent naval constructor of Italy, and the designer of her great ironclads. This gentleman makes concentration of fighting force a reason—or excuse—for building enormous vessels, claiming that in this way great war power is compacted and handled by one chief. He claims thus to carry out the Napoleonic maxim of concentration, and advocates, I am told, still larger ships for the future. The logical result would be a navy consisting of one ship half a mile long by an eighth of a mile beam. Seventy years passed without

naval warfare will account for these ideas being listened to by intelligent minds. Signor Brin's logic will, I am sure, fail to convince those persons much of whose lives have been passed afloat. What may come should the square formation prove successful, and other nations adopt it, it is needless now to inquire. Should ideas change, there would still be ships to be changed, and, after that, years of incessant drill afloat before tactics could be changed, and a whole Navy thus become expert and sea-hardened in its work. Should foreign ideas begin to change, it would then be time enough to think of an enemy's fleet approaching ours in a formation as solid, compact, and easily handled as our own. The time would be so much the longer, since entire conviction and desire to change would only come to them through crushing defeats of their formations by our more compact order—and hence, a resulting increase of time needed to build and man and drill new fleets.

I should be glad if our country might be the first to grasp the new methods demanded by new circumstances, and to see that the great, the masterful, power which steam gives us in place of sails is the ability to concentrate, to move swiftly here and there, still concentrated, and, finally, to strike the enemy almost as a solid mass.

I have desired to place before the members of the Institute this idea of a battle order as a fundamental one, and I leave it, therefore, for their reflection just as it stands, bare and unembellished; and I do this with intention. Many valuable additions may doubtless be made. A Polyphemus may be stationed at each angle of the square; a torpedo flotilla may hover in the rear ready to close when the smoke of hot action shall hide its approach; light and swift vessels for scouts and skirmishers may be added most effectively. These are the adjuncts of a fleet, however, not the fleet itself; and yet, it has seemed to me that for some years past the best intelligence of our Navy, its brightest minds, have concentrated their attention upon these adjuncts, rather than upon the fleet itself. Some officers have gone so far as to doubt the occurrence of fleet fighting in any future wars of the United States, and deny the necessity of preparation for it. I will not attempt to combat this error—this idea born of half a century's disuse of great maritime warfare, and opposed to the unchangeable doctrines of all warfare, which demand concentration of force as of first necessity. But that such ideas exist makes me the more satisfied to have had the privilege of setting before the Institute, in the present haze of doubt and speculation, a plain formation for battle

as a central fact, a thing to be reached out after, and which once established, will make many of the lesser problems easy of solution.

I do not claim that the solid square is the best system—I hope some one will soon suggest a better—but *something* of that kind must soon be obtained. The logic of the situation is plain. Warfare demands concentration. Concentration demands many ships in a small area, moving with swiftness, docility, and as one body. To meet this demand, the ships must be all extremely handy and all exactly alike, and squadron drill in this battle formation must be incessant. To those who agree with me, the practical results of this logic will be plain: we must *build and drill a homogeneous fleet* to the highest point of *evolutionary efficiency*. What should be the units composing this homogeneous fleet, it is not within the scope of this paper to discuss. The necessities of such a fleet, however, the resources of our nation, the known fleets of possible adversaries, are elements which would make it simple to define and describe the general type desirable and necessary.

I have laid before you a simple though difficult formation; it is crude, as all warfare is crude, but I believe it to be effective—unpolished, not unfinished. Let us seek, then, for the rough essentials of success first, afterward for those finenesses which are secondary; do not let these secondaries occupy us too seriously. Think of warfare not as of the watchmaker's trade, nor of the sewing-machine factory, but as of iron forging, where heavy and crushing but inexact blows are struck. War is a rough trade. Let us not ask for a razor edge upon our heavy cutlass. Let us not dream that fleets will ever lie three miles apart and let the finer-pointed gun-sights decide a battle. Great results are not thus attained. Battles of nations are not thus fought.

DISCUSSION.

Commander Horace Elmer.—*Mr. Chairman and Gentlemen*:—It has given me great pleasure to hear an essay upon Naval Tactics read before this Institute. It is a subject that seems to have been much neglected in the service of late, very naturally, perhaps, in view of the paramount importance of first obtaining ships and guns; but as now we seem to be in a fair way for getting a new navy, it is time we were thinking about how to fight it. It is especially pleasant to find an essayist of such decided views so frankly inviting criticism. I shall accept the invitation in the same spirit it is given.

I find that I disagree with the essayist so radically that it has been difficult, in the short space allowed for discussion, to arrange my remarks. Concentration is his text, and certainly the squares which he proposes as tactical units are the perfection of concentration; but it seems to me that in the importance he attaches to concentration, particularly in the lessons drawn from warfare on shore, he confounds strategy with tactics. It is, indeed, a Napoleonic maxim, verified too often in late wars to be gainsaid at this time, that victory goes to the heaviest battalions, and the general who, by happy combinations or rapid marches, can oppose twenty thousand of his own men to ten thousand of the enemy, has the victory already won; but when once opposed to the enemy in the open field, the domain of strategy is over and that of tactics begins; and in tactics, the experience of all recent wars has been in favor of thinner lines and greater dispersion, until now lines of battle have become nothing more than clouds of skirmishers. The Macedonian phalanx, as a tactical unit, much resembles the solid square proposed by the essayist, yet I scarcely think any army tactician would be bold enough to advocate a return to it at the present time.

In the days of Nelson and Vincent and Howe, there was virtually but one type of battle ship in all navies, and but one weapon to fight with—the gun. The ships were as nearly alike in all their qualities as the builder could make them; there were no hot journals nor sudden variations of steam at critical moments: they were all driven by the same wind and handling alike; nothing but good seamanship was required to keep them together; in other words, it was all in the hands of the captains. They had but one weapon to meet—the gun—and that effective only at comparatively short range. The battle tactics for such a fleet were easily comprised in the words of Nelson: "No captain can go far wrong who places his ship alongside that of an enemy." But at present battle ships are not built alike, nor is it probable they will be in our time. Old weapons have increased in power, new ones are developing. The high-powered gun, the torpedo, the ram, call not for a return to old principles, but an entirely new departure.

I will not dwell upon the practical difficulties to be encountered in keeping a fleet in such close order; that they will be great, the essayist acknowledges, and says that nothing but constant, unremitting drill will make it possible. Is it probable that all our heavy war ships, when built, will be kept constantly in commission and in fleet drill? Is it not more likely, judging the future by the past, that many of them will have to be put in fresh commission at the outbreak of hostilities, and, with others hastily gathered from different parts of the world, form our fleet? Would these tactics be practically possible under such circumstances?

The essayist acknowledges that the square would form an excellent target for the concentrated fire of the enemy's guns, but seems to rely upon wildness of fire to make the risk as little as possible. This is one great weakness of this formation: it makes no allowance for the accuracy and power of the new ordnance. A square of sixteen vessels in close order would extend at least a third of a mile in each direction. It would be exceeding poor practice that

could not hit somewhere inside of that, even at long range, and the Whitehead torpedo, however unreliable it may be, fired at ordinary targets, could scarcely fail to hit something, if directed at such a compact mass. Let us imagine for a moment the effect of such a hit disabling any of the leading vessels as the square comes down in compact order, at full speed, to the attack: the vessels in rear would pile up on those in front, or, in their endeavors to avoid collision, the square would be broken up in confusion. It would not need a Whitehead or even a well-placed shell to accomplish this: a hot journal would be almost as effective. The essayist admits that such a formation will not do for defensive purposes. I am perfectly willing to admit the importance and desirability of taking the offensive wherever practicable; but it is not always so, nor does victory lie always with the attacking fleet. I might instance, as bearing some resemblance, on a small scale, to Aboukir, the battle of Lake Champlain, where the attacking fleet, of the same nationality as at Aboukir, came down to the attack in the same gallant manner, bows on, but were defeated, probably because the gunnery practice was better.

Again, another fact which renders these tactics, even if theoretically desirable, practically impossible in the near future, is the admission of the essayist that the "fleet must be homogeneous, that vessels of great handiness and exactly alike must be built to make the handling of such squares possible." This, then, postpones the adoption of such tactics until the vexed question of construction is settled, and the best type adopted, if any such single vessel can be found. I feel safe in saying that will not be in our time. The rapid development of weapons of offense and defense makes the selection of any such single type more difficult every year.

I will now consider for a few moments the practical application of these tactics to battle as illustrated in the case proposed by the essayist; but, before going farther, I must protest against this idea of feinting at one wing and attacking another while charging down upon the enemy's line. Would a regiment, in column of divisions closed in mass, charging an enemy across an open field, first oblique to the right and then to the left, thus remaining under fire twice as long as necessary, in the vain delusion they were deceiving the enemy as to the point of attack—or, to make the analogy more complete, suppose the enemy on the other side were advancing to meet them—would not these oblique manœuvres be considered quite extraordinary? It seems to me as unreasonable to suppose that any advantage could be gained by thus manœuvring a fleet in the open sea and in the full presence of the enemy. In a fleet of sixteen vessels in order of battle, say in two lines indented, the vessel on the extreme right is well within the range of the guns of the vessel on the left, and the time distance between them at 12 knots is less than four minutes; so that one portion of a fleet can scarcely be crushed while the other is left out of action. That much, steam and high-powered guns have accomplished; and the more thoroughly we realize that fact, the truer, in my opinion, will be our conception of tactics. When once the formation for attack is decided upon, and the time for making it, the less manœuvring the better. But let us analyze the case proposed by the essayist: A fleet of sixteen vessels in close order (a solid

square), steering south, is approaching an enemy at high speed, say 12 knots; the enemy in line at the same speed. This will bring them together at the rate of a mile in less than 2½ minutes. The admiral in command of the square (I quote from the essay) signals fleet SE., when the sixteen vessels will change course simultaneously four points. To accomplish this, even with steam steering-gear, would take probably one minute. Then approaching still closer, the enemy's fire becoming hot, the admiral signals fleet SW., and these sixteen vessels turn eight points to starboard not instantly—nor in any degree resembling a school of fish, but through an advance of perhaps one thousand feet and a time of at least two minutes. I allow the shortest appreciable time for reading and answering the signal. If the fire was hot at the beginning, the fleets are certainly together before or by the time the turn is accomplished. The vessels of the square would have scant time to steady on their new course when the shock came. There would be little opportunity for deployment, were such a thing contemplated. The vessels of the enemy's left wing would meet them stem to stem, having but 45° to turn, while the square turned 90°, and the vessels of the right wing would bear down with their rams (turning 45° with starboard helm) upon the exposed broadsides of the left vessels of the square. It is not difficult to imagine what would become of this solid square after the first shock, should it ever succeed in reaching the enemy's line without being broken up. It seems to me the vessels would be piled upon one another in inextricable confusion, impossible to reform. Suppose that the leading vessels meet the rams of their opponents fairly: those in rear—for the formation is in close order, four deep—must get out of the way immediately or run into them. The time is fearfully short, and the fact is, there is no chance for any but the outer ones, in so compact a formation, to get out of the way; and they will have the rams of the enemy's right wing to meet. It must not be forgotten that the admiral in command of the square, though under fire confessedly hot, cannot use his own guns. He would not dare to run the risk: the smoke would hide his signals and, covering his square, render such delicate manœuvring impossible. These tactics, then, ignore whatever advantage there may be in long range and flat trajectory, and use the gun only when broadside to broadside, as in the days of the old carronades.

About two years ago I had the honor of reading a paper before this Institute on the subject of Naval Tactics. I then stated that, in my opinion, "concentration is the fallacy we are most likely to fall into by too closely following the military idea, and that it would seem a fundamental rule for all orders of battle that no vessel of a fleet should be in the water of another." Time and considerable thought upon the subject have only strengthened this conclusion. In view of the acknowledged unhandiness of the English groups of three, in the form of a scalene triangle, I then suggested that the groups consist of two vessels and the fleet be divided into pairs, as the best development of the group system. This was not a new idea, I discovered afterwards, having been proposed some years before by a French writer on tactics; but I was none the less pleased to hear, as an evidence that my prophecy as to the true evolution of modern tactics was not far wrong, that the English fleet, in their evolutions

last summer, under that distinguished tactician, Sir Geoffrey Hornby, discarded the group formations of three entirely and adopted a formation by pairs.

A theoretically perfect tactics should permit us to use to the best advantage all the weapons with which we are provided ; formations should be flexible, not easily destroyed, quickly reformed, adapted to defense as well as offense, and, to use the language of Admiral Randolph, R. N., "affording the utmost freedom to each ship of increasing or reducing speed, as well as altering course, or hauling out of action if disabled." It seems to me that the formation in solid squares answers none of these requirements.

Lieutenant H. O. RITTENHOUSE.—*Mr. Chairman and Gentlemen:*—Success in battle is the supreme consideration which should control every detail in the organization and development of naval force. The most vigorous and effective application of this force being no less essential to success than the possession of the force itself, we cannot afford to neglect the consideration of any system of tactics which might conduce to victory.

Of the value of concentration there can be no question, but I apprehend that it is concentration of attack rather than concentration of force which is generally regarded as a necessary condition of success. I make this distinction for the purpose of simplifying the discussion, and by no means as a criticism, for, if I understand the writer correctly, he advocates the massing of his force not because he regards the mass as an element of strength in itself, but because he believes it to be the best formation from which concentration of attack is made possible. Indeed, he plainly recognizes that this massing of material, and consequently of people, is in itself a source of danger; but he takes the risk of all its dangers in the hope of securing at least compensating advantages. It is at this point that I am unable to follow to his conclusion. I think too great a value is placed upon the advantages to which the system may lead, while its disadvantages are underestimated.

Whatever its merits or defects at other times, it must be judged alone by its qualities as a factor of battle. The advantages claimed are, that it enables the Admiral to make feints whereby the enemy may be deceived, and, finally, that a part or all of the vessels may be suddenly deployed in close action upon a selected portion of the enemy's force. I think these advantages are deceptive. To illustrate by the examples cited in the paper, we suppose the feint has been successful, and the reserves are hastening in one direction, while the real attack soon takes place in another. During this contest our vessels receive *some* damage, at least, and although the enemy's reserves arrive later, they are fresh to fulfil their important duties at a possibly more critical and decisive moment than if they had been engaged at first. Likewise, the advantage of throwing a superior force upon a smaller number of the enemy, whereby the enemy is left to throw *his* superior force upon the residue of our fleet, is not obvious. I do not go so far as to say that there can be no advantages in such measures, but only note that such advantages are not as great as they are sometimes thought to be.

The building of a fleet designed to fit a plan of tactics can be justified only

by showing that the advantages of the tactics are so great that all conflicting considerations should be subordinated to such plan. When force meets equal force on the open sea, attempts at deception will avail but little. In operations on shore, the topographical features invite and require the use of strategy; but at sea nothing is concealed, and when equal fleets meet on such even terms, the laws of compensation are so uniform that we are led to look for success in the more rapid and skillful handling of our rams, guns and torpedoes, rather than by any devices of manœuvring. The disadvantages which attach to the formation in solid square are numerous, and, I think, of greater moment than the paper discloses. We are met at the outset by the admitted fact that a fleet must be constructed to conform to the tactics, and no stronger statement can be made of the practical difficulties of the formation. If ramming is to constitute a material part of the action at close quarters, it is likely that the vessels of the homogeneous fleet would be fitted, to some extent at least, for such work—a fact which increases the difficulty, not to say danger, in time of peace, and might lead to confusion, if not disaster, in time of action.

To produce confusion, it is not necessary that accident should happen to one of the interior vessels of the square. An accident to any vessel, excepting those which happen to be in the rear, when steering a given course, would be equally unfortunate. It will be remembered that in the galley conflict referred to, the disastrous confusion was not due to a cause originating inside.

While the mass offers an attractive target to the enemy even at long range, it will be seen that the fire from the mass will be very much restricted, and when the fleet is steering on lines of the square or parallel with either diagonal (it is not probable that other courses would be in much use), the fire parallel to the keel would be restricted to a portion only of the outer lines.

Lieutenant CHARLES R. MILES.—*Mr. Chairman and Gentlemen:*—The question brought before us this evening presents a wide field for discussion, and the student of naval warfare must confess himself bewildered at the great number of intricate problems to be considered before anything like a definite conclusion can be reached in regard to the subject. The existing jealousies of the great powers of Europe may, at no distant day, give some of the well-equipped fleets of the period an opportunity to furnish us with valuable practicable lessons in battle tactics; but it will not be wise for us to pursue a "waiting policy," lest we ourselves should first be called upon to furnish those lessons and be found wanting. Naval officers have been urging upon the American people for years the necessity for building modern ships of war, and now that the prospect seems good for having a fleet of these ships entrusted to our care, it becomes us to look fairly at this question of battle tactics, and, by freely discussing it, to endeavor to form some idea of what tactical formation will be the best to fight successfully a modern fleet.

The paper under discussion presents very forcibly the value of compact formations for battle, but I doubt very much whether a candid consideration of the advantages and disadvantages of the solid squares will be in favor

of the adoption of such formations for battle. It appears to me that the only solid squares that are at all practicable are those composed of four and of nine ships. The former, that of four ships, has the disadvantage I should urge against the group system—that it would break up the fleet into small, detached squadrons, thus destroying its unity, and rendering it liable to be beaten in detail. The latter formation, that of nine ships, has a great disadvantage in having so many ships whose guns cannot be brought to bear upon the enemy while approaching him. This makes a very desirable formation to manœuvre from when the enemy's line of battle is reached, as illustrated by Commander Taylor in Figs. 12 and 13; but imagine the disheartening effect produced upon the officers and men of the silent ships in the rear and centre by being exposed to the galling, concentrated fire of the enemy without an opportunity to strike back until the enemy's line is reached.

I am disposed to favor concentration in the abstract, however, and believe that some other form of concentration not having the disadvantages of the solid square will be found in future fleet actions to possess the essential elements of success. I place much force upon the effect of breaking the enemy's line, should the enemy form in lines abreast in open order; for, with this feat accomplished by a fleet in compact order, the battle is half won. One of the principal axioms of warfare, be it on land or at sea, is that we must endeavor to catch the enemy unawares by out-manœuvring him, and then to overwhelm a portion of his force by the whole of our own. In order to accomplish this result, concentration must be resorted to at the critical moment of the final charge. Open-order formations may be employed as a means of spreading the fire of the enemy's fleet while endeavoring to out-manœuvre it, but they must be such open-order formations as will render it possible to form rapidly into the most advantageous compact order for striking the enemy the decisive blow when the opportune moment arrives.

All open-order formations are based, I take it, upon certain well-known principles of modern military tactics, but the advocates of these formations for naval battle tactics forget the difference in the character of the battles on land and those on the open sea. In the former, the conformation of the land, the presence of trees and of fortifications, etc., render the approach of an enemy slow and cautious, while the army acting on the defensive has a decided advantage. In the latter case, there is a smooth, unbroken surface, with no obstacle save the enemy's guns to prevent the two fleets from coming rapidly together. It, therefore, appears to me that we should liken naval battles to the cavalry charge, made by compact bodies moving at full speed, sweeping all before them, rather than to the movements of the slowly and cautiously advancing infantry in skirmish line.

I believe long lines either abreast or ahead to be very weak formations in which to make or receive an attack. First, because naval actions of the future, as Commodore Taylor says, will not degenerate into mere target practice at long range; for, with the great speed of the modern battle ship, and with the possibilities of her offensive weapons, the gun, the ram, and the torpedo, well considered, no commander, hoping for success, will hesitate to bring into effective

co-operation all the resources thus entrusted to him. It is needless for me to refer to the impotency of the ram and the torpedo at long range, or to their deadly effectiveness at close quarters, except to draw the conclusion more forcibly that, in order to produce the most effective co-operation of all the offensive weapons in a modern fleet, the commander must seek close action, and the earlier he brings his rams and torpedoes to the assistance of his guns the better, always providing that he obtains the advantage of position before doing so. The advocates of open order lay much stress upon the immunity thus obtained from the evil effects of concentrated fire, forgetting, apparently, that the time during which a fleet will be exposed to such a fire at anything like a comfortable distance for cool target practice will be very short indeed. Secondly, the line abreast, either with vessels in groups or in *echelon*, it seems to me, does not possess the necessary element of unity. The commander-in-chief does not have his vessels so much under his own control as in the compact order, and, as future actions will be fought, in all probability, in less time than even the most decisive battles were fought in the past, the necessity for compactness, to prevent early demoralization in the fleet, seems imperative.

I wish to propose, in place of the solid square, the double-*echelon* formation of two indented lines ; or, to make my meaning clearer, I would form the fleet in two wedge-shaped lines, one within the other, the apexes towards the enemy, and the sides of each wedge making an angle of 90°. The vessels of the inner line must take position opposite the intervals between the vessels of the outer line, making, as it were, two bow and quarter lines of vessels on each side of the wedge. I claim for this formation, which I shall name the battle angle, the following advantages :

1. The formation is compact and can be easily manœuvred.

2. All the vessels will be able to use one broadside and their bow guns while bearing down upon the enemy.

3. When the enemy's line is reached, each vessel in the rear can continue on her course without fear of colliding with a vessel of her own fleet, and thus use her ram and torpedoes most effectively at the first onslaught.

4. The angle within the inner line can be used as a shelter for the more lightly armored torpedo and dispatch boats and rams.

5. It affords abundant opportunity for the display of strategy, in breaking through the enemy's line and doubling on one wing of his fleet.

I wish here to take issue with Lieutenant Rittenhouse in regard to the importance of strategy in fleet actions. Of course, strategical manœuvres are much more difficult to accomplish on the open sea than on land, but the commander of a fleet must employ strategy as well as tactics, if he hopes to win victory. I hold there is plenty of room for the display of strategy in manœuvring a fleet to outwit an enemy ; and, although it may be difficult to deceive the enemy, yet that does not furnish sufficient excuse for neglecting to make an attempt to do so.

As the formation I have proposed would probably draw the concentrated fire of the enemy, while bearing down upon him the fleet might be deployed into two lines abreast in open order, preserving the relative positions of the

ships in the two lines as they were in the wedges. This formation could be maintained until near enough the enemy to discover the weak points in his line, when the fleet should form the battle angle again upon some designated ship, presumably the one opposite some weak point in the enemy's line.

I wish to state here that the formation I have advocated in line appears to be identical with that advocated by Commander Elmer in his paper on Naval Tactics, printed in No. 30 of the Proceedings of the Institute; and, further, that my formation of the wedge is simply that line formed in double *echelon.* I make this statement in justice to Commander Elmer, although, when I first conceived these formations, I had not seen his article.

I do not wish it understood that I advocate a rigid adherence to concentration under all circumstances; but this much I wish to assert—that, while the position of the enemy's fleet and the strategical intentions of the commander-in-chief may demand the open-order formation for the purpose of manœuvring into position, the concentrated, compact formation will be successfully resorted to for the final attack. After the fleets close and the signals become obscured, the fight must become a *mêlée*, and the best advice then, perhaps, for the individual commanders will be that given by Nelson to his captains at Trafalgar.

It may be a little irrelevant, perhaps, in this discussion to speak of the value of our present method of signalling; but as the success of fleet manœuvres in the future must depend upon the rapidity with which signals can be made and received, I shall claim the indulgence of the meeting for a moment longer, while I enter my protest against the continuance in use of the present methods. With two hostile fleets approaching each other at the rate of 12, 13, or perhaps 15 knots an hour, very little time can be given to the making and reading of signals; hence, some new and more rapid method should be devised.

It would be better, however, during battle, not to trust too much to signalling, even under the most favorable conditions. When the circumstances permit, all the possible features of the battle should be discussed beforehand by the admiral and his captains, and then, in case a signal is obscured or is wanting at the critical moment, the captains have their own knowledge of the plan of the battle to act upon. Nelson always adopted this method previous to his great actions, and by so doing he gained the confidence and thorough co-operation of his captains. If such were the case in those days, when plenty of time was given to the reading of signals, owing to the slowness of the approach of two hostile fleets, how much more important—nay, imperative—it is that each captain in the modern fleet should know what to do instantly, without waiting for a signal, when the enemy is approaching at the rate of 15 knots, and is, in all probability, directly upon him in less time than it would take to make out and answer a signal from the flagship!

Lieutenant C. D. Galloway.—*Mr. Chairman and Gentlemen:*—It is fair to assume that the tactics adopted by any nation will be known by all the other nations with which a conflict is likely to take place. This knowledge will enable fleet commanders to make their plans to a certain extent before the action begins.

Let us suppose, for example, two hostile fleets, *A* and *B*, approaching each other, each consisting of an equal number of vessels, say nine, not counting torpedo boats. The commander of fleet *A* adopts the tactics of the essayist, and advances to the attack in a solid square; while the commander of fleet *B* advances to meet him in single line of battle. I here choose the single line to oppose the solid square, rather than the indented or double line, in order that every gun that will train ahead or nearly ahead may be used upon the advancing square, which certainly offers a fine target for even extreme range. While approaching, therefore, the square will be subjected, from every ship in the line, to at least two rounds from each gun that can be brought to bear, while the line will be under the fire of only the leading ships of the square, and will naturally offer a much less favorable target. It is quite possible, also, that projectiles fired into the square may injure more than one vessel by passing through unarmored parts, creating *débris* and confusion, if not doing more serious damage.

Should the approaching square feint on either wing of the line, it will simply hold itself under fire from the whole line for a longer period and suffer more. A very important point to be noted here is the fact that the speed of the vessels of the square will be materially lessened by *any* change of direction, as mentioned by Commander Elmer. Another point to be noted is, that in all changes of direction of four points or more (the essayist suggests a change of eight points when feinting on one wing and attacking the other), as the vessels of the square are in close order, the rear ships in each column must slow almost to steerage way, or oblique at least two points before turning, in order to avoid running into the stern of the leading vessel, because, the pivoting point being invariably forward of the middle of a vessel, the stern of the leading vessel would extend at least 150 feet across the line of her former direction. This alone would greatly enhance the danger of manœuvring the square after the firing began, on account of smoke, as it would also in drill during fog or thick weather. My attention was called to this fact in 1880, by an officer of the Royal Navy attached to one of the ironclads of the Mediterranean fleet. In tactics other than that recommended by the essayist, this is avoided by the change of direction being more gradual, the vessels really steaming on an arc of small radius. Even in the square this is practicable, but I think the necessity for it increases the danger of fouling, and renders the fish-like manœuvring less practicable.

Let us now suppose *A*'s square has attacked the left of *B*'s line, and, while it is thus occupied, that the latter's right wing attacks the left flank of the square. Only the outside vessels of the square, in this case, would be able to do much execution, while the torpedo vessels belonging to fleet *B* would sweep around upon the right flank of the square, either attacking the vessels of the square on this flank or its torpedo boats; or else they would divide their attention between such an attack and in defending the vessels of their own right wing against an attack from the torpedo vessels of the enemy. Any damage thus done to the outside vessels of the square would materially weaken the effective force and utility of the inner ones, while any damage done to *one* of the vessels of

B's line would simply amount to the loss of *one* vessel. Should, however, the square break through the line, and assuming that it has swept away the vessels in its immediate path, suffering naturally some loss, the remaining vessels of the line need simply change from their original direction 16 points, and attack the rear of the square, continuing the attack while fleet *A* is reforming its square, or any other form of concentration demanded by the tactics proposed.

It appears to me that the tactics of the essayist subjects the vessels of *A*'s fleet not only to the entire force of its opponents, but also to the great danger of being destroyed by its own auto-mobile torpedoes, or of being fired into or rammed by its own vessels.

Lieutenant D. H. MAHAN.—*Mr. Chairman and Gentlemen:*—Besides the compact mass proposed by Commander Taylor, and the other formations suggested, I would like to propose a plan embracing the good points of both, as I think, and I hope I may either render my position good or receive such suggestions as may cause me to change my opinion. It is said, "In time of peace prepare for war"; so let us fight our battles to come now, that in the future we may be able to talk over our successful battles which have been.

The plan I would propose is, having nine ships, or any other number (but I take nine to place against Commander Taylor's nine), let us arrange them in a combination of two of the plans suggested, the double *echelon* and a partial line of battle; the centre three in line of battle, the two wings in *echelon*. This is the cruising formation, two or more cables' lengths apart both abeam and from astern to ahead. This formation of fleet can be more easily managed than either of those proposed. It is easy to form line of battle by the vessels in *echelon* moving at full speed into line. To change direction even to eight points is accomplished without the ahead and astern dilemma, and the position of *echelon* can be quickly regained by the wings. In all changes the three centre vessels wheel as one into the new formation, except when the signal, "Vessels right, or left, about" is made. For instance, there is a fleet in this formation heading E.; speed 9 knots, greatest possible speed 14 knots. A hostile fleet is reported from aloft bearing SE. Our admiral signals either, "Fleet SE. in *echelon*," or, "Fleet SE., left support." If the first is made, the centre wheels until heading SE.; the right slows until position is gained; the left increases speed to take position. If the second is made, each vessel of the right wing changes course to SE.; the centre wheels four points to SE. The left wing changes direction—No. 1 to SE., No. 2 to SSE., No. 3 to S. by E., forming in rear of the line of battle formed by the centre and right wing, on a line of bearing NE. and SW., and four or more cables' lengths in rear of that line of battle. On attack, these three vessels are held in reserve according to instructions well understood beforehand.

If it is found that the enemy is advancing in mass or square of nine vessels, I would attack in the *echelon* formation, and (the mass tactics being well understood) our captains would only have to consider what possible change would be made by the enemy. If the enemy should feint to the left, as his first change, it may be considered almost certain that his time will be too short to

attack the right; it is far different now from "Feint left face, cut right"; the distance travelled over by ships at full speed seems to have been disregarded by the writer. Our fleet has so far been advancing at 9 knots (the best manœuvring speed) in *echelon* formation; our admiral signals, "Full speed." This means he has determined to attack, and it is well understood that he will, with our centre, attack the enemy's van. Ram, if possible, is the order. The captains of the centre know this. There is no other signal to be watched for: all attention is given to the enemy. Fire is to be reserved until close aboard. Our centre strikes the enemy's van; the centre and rear of the enemy have to sheer boldly to the left and right, to avoid collision with their own vessels. Our right and left are advancing at 14 knots, straight as arrows, only allowing sufficient helm to strike decisive blows on the enemy's bows now open to us, and the result is what? 1st. The probable loss of our three centre vessels. 2d. The probable loss to the enemy of his three van vessels; three of his vessels, trying to escape to the left, run down by our right; three of his vessels, trying to escape to the right, run down by our left. The captains in the enemy's fleet have been trammelled by signals expected from their admiral. As soon as it is seen that they are bound to be hit by one of our approaching vessels, an effort is made to secure the best possible position to receive shock, but too late.

Suppose, however, that the position on heading SE. were the second, "Fleet SE., left support." Our centre would again attack the enemy's van. Our right would converge to attack the enemy's ships diverging towards it, or, better still, away from it. Our left, as support, has such a position that it can be moved to the right or the left, or support the centre by engaging any vessels which may have slipped through. Our left has also the advantage of being free from smoke and with more room to manœuvre. If, before the attack, the enemy should have changed so much to the left as to cause change of formation, the signal could be made, "Fleet E." or "Fleet NE.," when the centre and left would be in line of battle and the right wing in support. Readily concerted signals could be determined upon; for instance, "Full speed, left" would mean, "The left will attack enemy's van, fleet full speed to attack."

By these changes every movement is an advance, and only the vessels farthest from the enemy have need to slow down. Never make a movement in retreat when near the enemy. Nos. 7 and 8 of the writer's figures are just the positions I should like to see an enemy's fleet take, if I had a fleet of strong, swift ships close to it. By having a general understanding as to the movements of individual vessels, the necessity of signals can be done away with to a great extent. An admiral must depend upon his commodores and captains, and he can soon determine upon the character of each and assign them positions best suited to them. In such an engagement as I have described, the man who has the most grit will win. If the enemy's admiral falters, no matter how little, so much the worse for him. If our admiral falters, there is still a chance for us from the pluck of the commodores of the right and left wings.

If it is necessary to change course 16 or 12 points on sighting an enemy, signal, "Fleet W., vessels right, or left, about," whichever gains ground towards the enemy. Let us say right about, for example: then all turn one-

half circle to right; on completion of turn the centre advances at full speed; each of the other vessels takes up full speed, so as to retain position in *echelon*, heading W. Now the manœuvres can be resumed so as to head SW. or NW., or as you choose.

These few remarks are made to show that this formation has the following advantages: 1st. No ahead or astern line, unless one wing acts as support, and in that case the support is sufficiently far from the main fleet to avoid fouling. 2d. Easy to change to another formation. 3d. More space given for calculation than in mass or line of battle formation. 4th. Being in open order, there is less liability of being struck by a shot intended for another vessel.

Commander H. C. TAYLOR.—*Mr. Chairman and Gentlemen*:—In the opening remarks of my paper I stated that my ideas were not at all in line with modern naval thought. In other words, I quite expected the severe criticism which this discussion has developed. This criticism has come from most able and intelligent officers. It is in all probability correct and just, for it expresses the sentiment of a majority of the thinking men of our Navy. While unable to change my own convictions, based upon some experience, thought and study, I shall not imitate the solitary juror who complained of the obstinacy of the eleven other jurymen. I shall, therefore, make some explanations and clear away some misapprehension of my meaning, not hoping, however, that even then we shall be much closer together.

In the first place, when it was determined to build a navy, and suggestions were invited as to future ships, it seemed to me a logical course to consider what future fleets could inflict most damage upon an enemy; and to consider then what form and class of vessel would make that future fleet a possibility. To determine what form or method of fleet was best for our needs, it seemed logical also to observe the European armaments, to note without prejudice the points where they have failed to obey the great laws which thousands of years of warfare have made for us, and, avoiding their defects, to prepare by more skillful methods to take advantage of those defects in case of a future war.

Thus, my desire being to deduce the ship from the necessities of the fleet and its tactics, I am quite at odds with the excellent and valuable remarks of Commander Elmer, which open with the statement that naval tactics have been "much neglected in the service of late, very naturally, perhaps, in view of the paramount importance of first obtaining ships and guns." He intimates that a fleet of Nelson's or Howe's time was more easily kept together than a modern steam fleet, being driven by the same wind, and having no hot journals to contend with. I cannot agree that this is a fact. I think flaws and baffling winds were greater enemies to compact formations in the days of sails than are the steam accidents of the present day. That battle ships are not built alike is in my opinion much to be regretted, but it is, I confess, a good reason for objecting to compact formations. But I urge that they can be and ought to be built alike, in order that we may have and use such formations.

Though I have referred to both the sailing period and the galley period, I should here say that the history and laws of warfare afloat during the galley

period, which counted thousands of years against the sailing period's centuries, have been my principal reliance in deducing effective rules for our present guidance under steam. Commander Elmer believes that "the high-powered gun, the torpedo, and the ram, call not for a return to old principles, but for an entirely new departure." I do not agree with him. Fundamental principles of warfare do not change. No new departure is needed. The gun, ram, and torpedo will work with these principles, or may, perhaps, retard them somewhat, but they can neither change nor destroy them.

The system I advocate does not contemplate for its unit "heavy war ships," as I understand Commander Elmer to use the term. The use of such ships has forced upon European navies formations and tactics hopelessly faulty. Formations and tactics to defeat theirs are possible only with a different unit of fleet, a smaller, cheaper, slower, but quicker-handling unit. It will give me pleasure at some future day to lay before my able critics and good friends a general idea of the unit which I finally suggested as the result of what seems to me a course of logical naval deduction.

I am willing to consider as of great weight the objection to the square as a target for the enemy's fire. I can imagine circumstances in which it would result in the loss of a battle. I consider, however, the advantage I have pointed out to outweigh this defect.

I noted in my paper that there were some rare exceptions to an attacking fleet being successful. The battle of Lake Champlain is one. A few others are recorded in naval histories.

I contemplate the changes of direction referred to by Commander Elmer as being made while out of close or destructive range; and I expected the turnings to be made *simultaneously*, not, as he seems to think, *instantly*. To go further into possible details would prove too great a trespass upon your time. It is evident to me, however, that the power of feinting with a compact formation may be employed when at a long distance from the enemy, and to such a degree as to throw into serious confusion any elongated formation which attempts changes of front in order to meet the attack. I had no wish to ignore long ranges and flat trajectories, but one of my chief purposes was to protest against the undue weight given to this and other improvements of details, in considering methods of fighting. It is asked, Would regiments, in charging, oblique in order to make feints? Had these regiments means of being transported smoothly and swiftly across the space intervening between them and their enemy's line, it is my opinion that they would employ this obliquing though exposed to heavy fire while so doing.

The explanations I have made in answer to Commander Elmer's criticisms will cover much of the ground of the remarks of the other officers—remarks giving evidence of careful thought and a thorough understanding of the subject. I wish to accede at once to the statement of Lieutenant Rittenhouse that it is concentration of attack rather than concentration of force that is to be desired and sought for. I recognize, also, the wisdom of his remark that "the building of a fleet designed to fit a plan of tactics can only be justified by showing that the advantages of the tactics are so great that all conflicting considerations

should be subordinated to such plan." But my claim is that any ordinary system of tactics will have those great advantages if it is made effective by building ships and fleets to fit it.

As regards Lieutenant Miles's valuable suggestion of a double wedge, I have only to say that if the angle of the wedge is 90°, he produces something very similar to the half of a solid square. I desire compactness, but have no special fondness for the square, and am quite ready to believe that the wedge may prove highly effective. The instant, however, it is attempted to fill in the space between the wings by weaker vessels, his formation has the same defect as the hollow square proposed some years ago by Lieutenant Mason, who filled the inner space with vessels not belonging to the formation proper, and thus effectively separated the sides of the square from each other and prevented mutual support. Omitting this feature, the hollow square is not an undesirable form of concentration, and with the same omission I consider Lieutenant Miles's wedge practicable and effective.

In Lieutenant Galloway's discussion of this formation, he expresses a belief that vessels would run into the sterns of their leaders. If I understand him correctly, he has misapprehended my meaning. I have not deemed it possible to have any wheeling or following of leaders in a compact formation like this. At the signal, "Fleet NW.," each vessel turns NW. at the same moment, preserving unchanged the bearings of the lines and columns. It is not intended that any ship should continue her course until she arrives at the point where her leader turned, and so run the danger of fouling him. Lieutenant Galloway also suggests that after the square has attacked the enemy's left, the enemy's right wing may attack the left face of the square. In answer to this, I may say that before delivering the attack the square would disengage and reach the enemy's front in detached lines or columns, as shown in the figures.

Lieutenant Mahan has suggested a formation which appears to me to have much strength, but I am disposed to believe any formation defective that calls for wheelings and new alignments while manœuvring in the presence of an enemy. This it is that has made me desire a formation which need not be changed during preliminary evolutions. I have not disregarded the short times and great distances of our modern ships at full speed, but have, on the contrary, felt that fact to constitute a great danger to wheelings and fresh alignments.

Throughout this discussion, from which I have derived great benefit, though not a change of opinion, I seem to observe that the examples of European navies have considerable influence upon the views of our officers. This is natural; but I submit that it is not wise to defer too much to systems of warfare which have never endured the tests of war. English admirals have used their skill as tacticians to procure the best formations possible with such units as they possess. Nor am I surprised that their conclusions should nearly coincide with those of the talented officers of our own Navy, whose study of the subject makes their criticism so valuable. But if their units are oversized, clumsy, and expensive; if the fleets formed of them are strangely ineffective in proportion to their cost; if their tactics are vague and feeble; and, finally, if we, having no units, no fleets, no tactics, are about to get them, why

shall we not first say what tactics and fleets will prevail against European systems, and then provide the unit ships of a kind to make those fleets possible? Whatever we may decide, therefore, as to the best fleet and formation, do not let us so decide because the "modern ship" will or will not fit it. However great may be my error, this would be a greater one.

The CHAIRMAN.—*Gentlemen:*—The discussion has anticipated many of the thoughts which had occurred to me with regard to the subject under consideration. Another form of expression may, however, give some interest to a brief statement of ideas which have been presented already so well and forcibly.

A fleet of sixteen vessels in single column, at one cable distance, occupies a length of one mile and a half. If formed in square, at two cables' distance, which may be estimated as the least distance, in that order, for manœuvring under steam and at full speed, the side of the square would be six and the diagonal eight and a half cables. In the first formation, supposing the van ship at rest, the rear vessel, at a speed of twelve knots, would reach the van in seven and a half minutes. If the leading ship proceeds at half speed, the rear ship would require fifteen minutes to overtake the van. Similarly, if in square, steering in the direction of a side and its parallels, the rear squadron could reach the van in from three to six minutes. In the old battle formation, a single column upon a line of bearing, the ships to leeward were liable to be thrown out of action, a disability which, it is evident, could not be imposed upon a steam fleet of the present day. These two formations, the line of single ships and the square, present the extreme cases of dispersion and of concentration of the fleet.

The square insures the advantages of simplicity in manœuvring and deployment of divisions, of close supervision by the commander-in-chief, and of bringing with the greatest rapidity one part of the fleet to the support or relief of another. It imposes some disabilities. The ramming power of a fleet of sixteen vessels in square is reduced, primarily, to that of four ships, if steering upon a side of the square and its parallels, or to that of seven vessels, if heading in the direction of a diagonal. Similarly, the amount of gun fire is reduced as follows: In a square of four vessels, one-half or one-fourth, according as the ships head in the direction of a side or a diagonal; in a square of nine vessels, two-thirds or four-ninths; and in a square composed of sixteen vessels, three-fourths or nine-sixteenths, respectively. The inner ships lose all their circle of fire. Indeed, it does not appear that the enclosed vessels have any defensive power while that formation is maintained, nor any offensive power, except that of proceeding to points where their latent force may become effective.

The square offers a broad mark to the distant fire of an enemy, and, although fleets will probably approach with such rapidity that not more than two rounds may be fired from bow guns, the guns being again loaded and ready for the moment of collision, this must be noted as a serious disadvantage.

In the square, the attention of commanders must be given largely to the relative bearings and distances of their consorts, while in the presence of the

enemy, when his mind should be relieved, as far as possible, from considerations of tactics, distances, angles, and compass courses. The general plans of action will have been formed and communicated by the commander-in-chief to his captains; and, in these last moments, his attention should not be absorbed in manœuvres to attain a battle formation. His efforts should be directed rather to the transfer of his battle line, already formed, to a position from which the attack may be delivered as he would prefer, in the prevailing condition of the wind and sea.

In the event of surprise, as from sudden fog-lifting or at night, with the enemy close aboard, these disadvantages would be, apparently, somewhat increased. It would be difficult to change the formation promptly. The leading ships of the square would probably charge, with an intention of ramming; but it is thought that, in a fleet about to charge, no ship should be directly in the wake of a leader, unless in very open order. The sudden disability of the commander of a leading ship, or any of the accidents of war occurring in the van, might precipitate disaster. The square is considered a bad formation in which to receive a sudden charge of some of the enemy's ships, if equal in number to the front of the square.

The composition of the battle fleet is an essential part of this problem. Some think that each ship of the line of battle will be attended by one or two sea-going torpedo vessels. Others maintain that it will be better to compose the line of heavy ships of great and equal speed, strengthened for ramming, and carrying powerful batteries. The existing opinion and practice appear opposed to the employment of vessels solely as rams, and it is not likely that they will have a place in the line of battle. The naval mind, throughout the world, is bent on ramming with any ship which may enter the line, irrespective of her artillery power; and, for this object, a strong and sharp bow, speed, and weight of vessel, are necessary. These qualities can be obtained without sacrifice of battery.

Let us consider an example of the necessary size and speed of a vessel for effective ramming. At Mobile Bay, the Monongahela, of about two thousand tons displacement, when ramming the ironclad Tennessee the second time, struck her upon the beam nearly at a right angle. The speed of the former, at the moment of striking, exceeded ten knots; but both ships had their helms a-port, the Monongahela endeavoring to deliver a perpendicular blow, and the Tennessee striving to sheer clear of her antagonist or to make the blow a glancing one. At ten knots speed, the perpendicular or direct blow would have amounted to about nine thousand foot-tons. But the blow was not a direct one, and the peculiar form of the Tennessee's side secured great structural strength and resistance. The Tennessee heeled far over and sheered rapidly away from the bow of her adversary. A part of the blow was absorbed in the destruction of the Monongahela's bow. Of course, the Tennessee's side did not take up instantaneously the remaining energy of the blow, but it is thought that had her side been straight it must have been penetrated. The force exerted by a ram, striking perpendicularly, varies directly as the weight and as the square of the speed of the ram. The Trenton could deliver, there-

fore, at a speed of twelve knots, a blow of about twenty-four thousand foot-tons. A large portion of the energy of a ram will be spent otherwise than in producing rupture at the point of impact. But it is believed that only an exterior structure, similar to the wedge shape of the Tennessee's side, powerfully braced upon the beams of a ship, could be hopefully opposed to the direct blow of sixty thousand foot-tons, given by the sharp bow of a ship of six thousand tons displacement, at a speed of fifteen knots.

Assuming that the battle line will be composed of heavy armored ships, with great speed and powerful batteries, does the square provide the greatest development of the ram and the gun, as the two most effective and reliable forces of the fleet? The effort should be to strike as heavy a blow as possible at the beginning of the fight, and we should look for a formation which will enable the ships to deliver that blow in unison. The square does not permit all the ships to participate in an attack, either with ram or guns. But the essayist says, "The square is to be maintained only until close action is joined, when deployment follows, the columns of the square diverge, and each ship takes room for fighting." It is submitted that the deployment is too late, and may result in partial or successive assaults by divisions of the fleet, or in one division sustaining the first onset of the entire fleet of the enemy.

The design and argument of the essayist appear to rest in this change of formation in the immediate presence of the enemy, precisely executed by a highly drilled fleet, thus keeping the enemy in ignorance of the point at which the blow will fall, and taking advantage of any peculiarity of his formation. It is a daring conception. The essayist concedes, practically, that the square can neither attack nor defend, but he uses it as the element from which he will develop his battle in the face of the enemy. The aim is high, and he will deserve success.

The fleet should cruise habitually in the battle formation, and the line of battle should be that in which the offensive and defensive powers of all the ships may be instantly employed. The double line of battle, in which the unit is a group of two ships, exemplifies this principle. Some advantages of this order were ably stated by the present Head of the Department of Seamanship and Naval Tactics, in a paper read before the Institute in January, 1884. It affords some other facilities besides those noted by Commander Elmer. In this formation, the rear ship of a group may keep its station four or five points abaft the beam, or it may be shifted quickly from one quarter to the other. Manœuvring is quite as simple as in the single line. When in double column, the broadsides of every ship are preserved; in line, the way is clear for each as a ram; and, at nearly all other angles, the double *echelon* formed gives scope for all the powers of the fleet. The leading ship has the task of maintaining its correct alignment and distance reduced to the least difficulty. The rear ships have only to watch their leaders and to follow up the attack of the leading line. Angles and relative bearings of ships find their utmost simplicity. The lookout ships should be stationed upon the flanks in front and rear, and, having signalled the number and formation of the enemy, they should assemble in rear of the double line and form, with the torpedo vessels, the reserve of the fleet. The front should equal or exceed that presented by

the enemy, and the reserve of the double line affords a means of prolongation, either deliberately or suddenly, when considered necessary or desirable.

It is thought that the double line gives a powerful concentration, that concentration which subjects a number or all of the enemy's ships to a second blow from the supporting line swiftly following the first, or that other form of concentration which is effected simultaneously by enveloping and turning upon the flanks of the enemy.

Since we must concede to the enemy's ships a speed equal to that of our own fleet, the problem of doubling upon a part of his line has now an additional difficulty. And if one steam fleet doubles on a part of the other, why cannot the disengaged ships double also? If the formation is a good one, manœuvres will not avail much against an enemy of equal force: the victory will rest with the fleet which possesses the superior preparation, cohesiveness, skill, and endurance.

Commander H. C. TAYLOR.—*Mr. Chairman*:—Permit me to say, in answer to your fears that the deployment of the square may be too late and may thus result in disaster, that the deployment would be ordered when closing with the enemy, and the time for it would be determined by the admiral, sooner or later, as the firing became hotter and collisions impended. You consider, very justly, that a powerful concentration is obtained by the double line in attack. I submit to your judgment that the solid square of nine ships only adds another line to your proposed line of attack, while it ensures a formation equal at all points and in all directions.

Commander HORACE ELMER.—*Mr. Chairman*:—I move that a vote of thanks be tendered to Commander Taylor for his very interesting and valuable paper.

The motion was carried, and the meeting then adjourned.

SOME PRACTICAL HINTS ABOUT FORTIFICATIONS.

By J. C. Little, late Captain of Artillery and Ordnance Officer at Fort Fisher.

At the bombardment of Fort Fisher, the ironclads took up a position to the NE. of the fort, and devoted their attention to the land, or north, front of the fort. On this front were some 20 guns, comprising 8-inch Columbiads, rifled 32s, smooth-bore 32s and 24s, etc. All these guns were mounted in barbette, with heavy traverses between the gun chambers. Without any difficulty or delay the fleet dismounted all these guns except one in the NE. corner of the fort. Nearly all, if not all, were dismounted by being struck square on the muzzle by heavy shot or shell. But the 6.4-inch rifle in the NE. corner, though fired at for three days continuously, was never touched, and was in condition for service when the fort fell. I tried to ascertain the reason why this was the only gun that stood, while all the others were dismounted, and my conclusions led me to a new plan for seacoast fortifications.

These barbette guns showed plainly against the sky, the works and gun presenting an appearance like Fig. 1. The muzzle stood out clear and offered a perfect mark, while the course of the shot could also be plainly traced and the aim corrected. Hence, not more than two or three shots were needed at each of *these guns* to disable them. The gun in the NE. corner was *marked* by a traverse behind it, so that it could not be

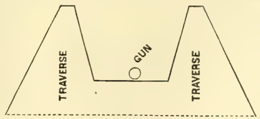


Fig. 1.

plainly seen, nor could the shot (plunging into the traverse) be traced to correct the aim (Fig. 2). When ordnance was such that ships could lie yardarm to yardarm and hammer away for an hour, it was important that seacoast guns should have a plunging fire. Now that vessels can lie off so far, the small elevations of 30 to 60 feet give an advantage very slight—not to be weighed against other and more patent advantages. This advantage my plan sacrifices.

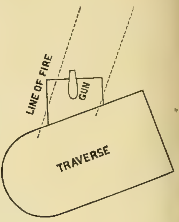


Fig. 2.

I claim for my plan (Fig. 3) the following advantages:

1. The gun, being masked by the main works, cannot be easily struck.

2. The slope of the parapets being parts of the same line, riflemen from their berm can sweep the parapet of the gun works in comparative safety, and aim by night or in smoke as effectually as by day.

3. The magazines, being under traverses between the guns, are safe and convenient.

4. The middle ditch exposes an assaulting column to hand grenades from the rifle berm, or to shells with 3 to 5-second fuses rolled down the slope.

5. Small sally-ports through main works allow easy communication, while an arrangement of the ceiling of the sally-port in shape of a trap would block the sally-port with sand in an instant.

6. Bomb proofs perfectly secure.

7. A middle ditch which could be raked with canister by field guns from either end.

8. An inner covered way which affords safe communication everywhere.

9. Works safe from captured guns, as the guns cannot be turned against the garrison, the interior of fort being secured by main works.

Should it be deemed advisable, secret mines could be placed along $C'C''$ which, while too low to be reached by a fire from without over the crest of the gun works, would throw all the sand along AB on an assaulting column in middle ditch without affecting seriously the strength of the main works. Of course, these mines would be sprung from bomb proofs, and would be of just enough force to move AB without affecting the rest of main works.

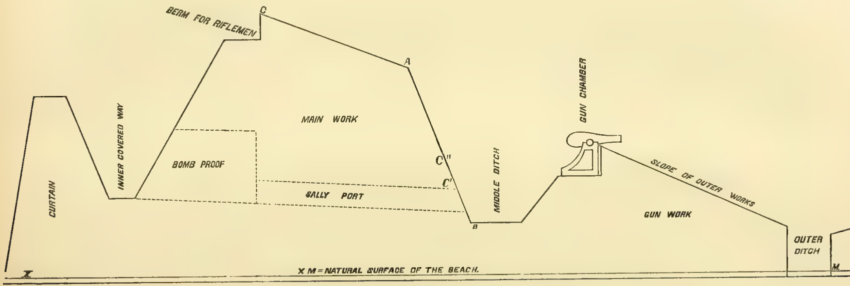

BERM FOR RIFLEMEN
C
A
CURTAIN
INNER COVERED WAY
MAIN WORK
BOMB PROOF
SALLY PORT
C''
C'
B
MIDDLE DITCH
GUN CHAMBER
SLOPE OF OUTER WORKS
GUN WORK
OUTER DITCH
X
M
X M = NATURAL SURFACE OF THE BEACH.

FIG. 3.

One great disadvantage seacoast defenses labor under is that the enemy can fill the works with smoke from bursting shell. At Fort Fisher the smoke from this source was so dense as to hide the ocean; in fact, nothing could be seen for 50 yards. The only way to obviate this is to scatter the guns—putting them, say, 300 to 400 yards apart. This, of course, would necessitate heavy garrisons.

In erecting works, traverses should be freely used, but they should project very little forward of the crest of the gun works, as every inch advance cuts off the range of the gun without proportionally protecting the chambers. Owing to projecting traverses at Fort Fisher, none of the heavy guns—all of which were on the east front—could be brought to bear upon the main station of the fleet, which was to the NE. of the fort.

The thickness of the main works (from *C* to *A*) would have to be determined by experiment. It should be at least once and a half the penetrating range of the heaviest guns; that is, if Krupp can drive a shell 40 feet into a sandbank, *CA* should be at least 60 feet.

Of course, the plan of the works allows the necessary traverses to prevent flanking fire. They could be placed on the gun parapets, or on the inner works, or on both, according to the necessities arising from the topographical features of the surroundings of the works.

U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

NOTES ON THE LITERATURE OF EXPLOSIVES.*

By Charles E. Munroe.

No. X.

Among our new exchanges we are pleased to note the *Transactions of the Technical Society of the Pacific Coast*, published in San Francisco, Cal. The society was instituted April, 1884, with Colonel Geo. H. Mendell, U. S. A., as president, and has already entered upon the publication of the second volume of its transactions. Besides other papers of interest, we find several devoted to the subject of explosives. Thus Dr. Fred. H. Jenssen treats of the "Causes of Explosions in the Manufacture of High Explosives," **1**, 200; 1884, and finds that these may, in general, be traced to—1. improper construction and faulty arrangement of the works and machines; 2. carelessness on the part of the workmen; 3. maliciousness. Under the first head, he considers the relative dangers of the two principal processes, Nobel's and Mowbray's, for the manufacture of nitroglycerin. He employs in his own practice two Nobel apparatus, having a productive capacity of one ton, built side by side. By this means, three men can run the works and produce six to eight tons of nitroglycerin daily, while a few laborers are engaged on outside work. After the danger of firing in the converter, comes that from overheating when the nitroglycerin is precipitated. As the acid nitroglycerin is very sensitive and decomposes at 100° F., it is essential that the charge in the converter should bé run into a very large body of water, and that this water should be changed as soon as possible. Under no circumstances should acid nitroglycerin be stored over-night. Care should be taken that the pipe lines between

* As it is proposed to continue these Notes from time to time, authors, publishers and manufacturers will do the writer a favor by sending him copies of their papers, publications or trade circulars.

the tanks do not cross or approach near steam or hot-water pipes. Accidents arise from the wash waters, since they carry nitroglycerin partly in suspension and partly attached to the solid impurities in the water. For economy's sake, as well as to avoid accidents, arrangements should be made to catch as much of this as possible before discharging the water; but where the water is run off, it should be led through earthenware or lead pipe by the shortest line to the river, bay or well. If wooden conduits are used, they become saturated with nitroglycerin and acids. Hence they should be well covered to protect them from the sun, which causes decomposition. The effect of the sun's rays was seen at one factory where no provision had been made to catch the traces of nitroglycerin, and where the wash waters ran a short distance over a sandy beach before entering the river. The result was that on a hot summer's day red fumes were observed rising from the ground, and a heavy explosion soon occurred. Even where wells are used, there is danger from these wash waters. For instance, at a factory where these waters were led through a ditch in rocky ground, it was found that considerable quantities of the explosive had accumulated in the fissures in the rock. Numerous unsuccessful efforts were made to remove this, and finally the ditch was dammed, so as to keep the explosive covered with water. Several years after, the ditch was struck by lightning, and an explosion ensued which damaged the buildings in the vicinity severely and hurled large masses of the rock to considerable distances. From the sensitive nature of acid nitroglycerin, it naturally follows that the recovery of the spent acids is attended with great danger.

In the making of the dynamite, there is little danger if the absorbent is itself a safe one, and is not too warm, and the proper precautions regarding the use of metal tools are taken. The buildings should be heated by hot water or steam, and the pipes so covered as to prevent the dust from settling upon them, or, if it does settle, they should be frequently cleaned. This dust is a constant source of danger, especially in the making of explosive gelatine, where nitro-cellulose is used in the dry state and finely pulverized. In all the rooms, the windows should be shaded to prevent the direct sunlight from falling on the explosive. Similar precautions are to be taken in the packing department; and here the author describes the devices which may be safely used.

The last two causes are discussed at length, and among instances

of maliciousness, the writer cites one from his own experience where a quantity of tips from phosphorus matches were placed in a bag of infusorial earth, and were not discovered until the earth had been made up into dynamite. The essay is a practical one, by a man of many years' experience, and deserves more space than we can give it. It was followed by a discussion, which is printed in the *Trans.* **2,** 16; 1886.

"A Talk about Explosives," by Wm. R. Quinan, **2,** 109; 1886, gives a brief historical survey of the development of gunpowder, and of the growth of the explosive industry on the Pacific Coast; it then describes various explosive compounds and mixtures, and discusses their mode of action and efficiency, and concludes with a résumé of portions of Berthelot's thermo-chemical researches, and of Debus'* paper on the chemical theory of gunpowder.

The most novel among these essays is that by L. J. Le Conte, **2,** 223; 1885, bearing the title "Are Not Dynamite Catastrophes Intimately Associated with Electric Phenomena?" The author has for the past ten years noted the circumstances attending the accidental explosions which so frequently occur on the Pacific Coast, and he has found that, with the exception of such explosions as occur during thunderstorms, these explosions take place during the violent, desiccating north-wind storms peculiar to the winter and spring months in California, but occasionally happening in midsummer. These winds have a velocity of fifty miles per hour, and a relative humidity of about 20 per cent., but frequently as low as 15 per cent., though seldom as low as 5 per cent. During the prevalence of these winds a prodigious amount of electricity is developed by the friction of clothing, especially when walking against the wind. One can thus easily generate a spark *half an inch long*. The phenomenon is also strongly marked in horses at work, the electricity causing their manes and tails to bristle to a remarkable extent. The author finds in this electricity the exciting cause of these explosions, and in the *dust* that prevails in the works, the medium through which explosion is propagated, a dust explosion always preceding the explosion of the mass of powder. These explosions occur on the third or fourth day of the storm. To test his theory, the author made four predictions in 1882 and 1883, and in each case an explosion of considerable magni-

* Proc. Nav. Inst. **9,** 1, 1883.

tude occurred. To guard against these accidents, the author suggests the use of steam jets, such as have been so successfully applied in cotton and flour mills and in coal mines.

The author believes that explosions during thunderstorms are caused by the *return shock*, and hence he considers it a fundamental precaution that all good conductors of electricity should be prohibited from entering any building where explosives are stored or manufactured, and believes it would be a wholesome rule not to allow such conductors to be anywhere near the premises.

M. Hay and O. Masson have studied the "Elementary Composition of Nitroglycerol"—*Proc. Roy. Soc. Edin.* **32**, 87. After reference to former work on nitroglycerol by Williamson and others, the authors detail their process for preparing the compound. One part by weight of pure glycerol was added drop by drop to 2 parts nitric acid (1.49) and 6 parts sulphuric acid (sp. gr. 1.84), the two being kept below 10°. After ten minutes the mixture was thrown into water, and the precipitated oil was well washed and dried at 60–80°, finally being kept in a vacuum for twelve days over sulphuric acid, sp. gr. at 14.5° = 1.601. The combustion was made by weighing out 0.2—0.4 gram into a porcelain boat containing fine copper oxide, and then adding another layer of the oxide. After the boat had been introduced into the combustion tube, its contents were thoroughly mixed with the oxide in the tube; then the combustion was proceeded with in the ordinary way. Nitrogen determinations were 18.25 and 18.06 (theory 18.5). Difference in preparation does not cause a difference in composition. From these results and those obtained by Hay (next abstract), the authors conclude that the generally accepted constitution of trinitroglycerol is correct.

M. Hay gives in the *Trans. Roy. Soc. Edin.* **32**, 67, the results of his study of the "Chemistry of Nitroglycerol." From the resemblance of nitroglycerol to the nitrites in its physiological and therapeutical properties, the author was at first inclined to regard it as being a glyceryl nitrite instead of a nitrate, but the result of a further investigation did not confirm this view. Railton and others have stated that nitroglycerol when treated with alcoholic potash yields glycerol and potassium nitrate. The statement is incorrect: the decomposition is of a complex nature. No glycerol is obtained, as it is oxidized at the expense of the NO_3 groups, about two-thirds of which suffer

reduction to the nitrous condition, only about one-third being found as nitrate at the end of the reaction. The other products of the reaction are potassium acetate, oxalate and formate, a small amount of ammonia, and a reddish-brown resinous substance, which gives a dark color to the liquid. Numerous determinations of the amount of nitrite formed showed that 100 parts of nitroglycerol gave from 34.14 to 35.24 parts of nitrous anhydride. (If two-thirds of the nitrogen were converted into nitrous anhydride, the amount would be 33.48.) As it was also found that 5 mols. of potash were required to decompose 1 mol. of nitroglycerol, it seems that the principal reaction may be expressed by the equation

$$C_3H_5(O.NO_2)_3 + 5KOH = KNO_3 + 2KNO_2 + CH_3.COOK + H.COOK + 3H_2O.$$

The reaction is the same with either alcoholic or aqueous potash, but it is very slow in the latter case, owing to the sparing solubility of nitroglycerol in water.

Ammonia and alkaline carbonates act in a manner similar to potash. The same may be said for sodium hydrogen phosphate, but the reaction is much less powerful, whilst sodium chloride exerts hardly any action. Hydrochloric acid acts less powerfully than alkaline carbonates, and sulphuric acid (1 : 10) less powerfully still, whilst the concentrated acid has no action. De Vrij's statement that nitroglycerol is decomposed by sulphuretted hydrogen is not correct. The alkaline sulphides decompose nitroglycerol, sulphur being precipitated, and the reaction is rapid, and seems to be promoted by the sulphur; yet the particular part played by that element has not been ascertained. Hot water decomposes nitroglycerol slowly. The amount of glycerol formed from a given weight of glycerol agrees fairly with the assumption of its being glyceryl trinitrate.

As different statements have been made as to the physical characters of nitroglycerol, the author has prepared it in a state of purity, and finds that it is perfectly colorless, and remains so even when exposed to air. It keeps equally well in water or alcohol. Heated on the water-bath, no change occurs unless acids or alkalis are present.

1 gram of nitroglycerol dissolves in 800 cm. of water; in 10.5 cm. alcohol (sp. gr. 0.846); in 1 cm. methyl alcohol (sp. gr. 0.814); in 4 cm. methylated spirits (sp. gr. 0.830); in 18 cm. amyl alcohol; in less than 1 cm. benzene; in 120 cm. carbon bisulphide; in all proportions in ether, chloroform, glacial acetic acid and phenol, and sparingly in glycerol.

Nitroglycerol can be estimated with tolerable accuracy by determining the amount of nitrite formed by boiling with alcoholic potash, and assuming that 100 parts of nitroglycerol yield 33.48 parts of nitrous anhydride. (Abst. *Jour. Chem. Soc.* p. 742, *July*, 1885.)

The "Physiological Action of Nitroglycerol" has been studied by M. Hay (*Chem. Centr.* 108, 1884), and he states that the poisonous action of nitroglycerol cannot be explained by the action of its constituents. The symptoms are similar to those produced by amyl and potassium nitrites. The author found that, of the three NO_3 groups present in nitroglycerol, only one is removed by the action of alkalis as nitrate, the other two combining with the alkali as nitrite, whilst the oxygen set free oxidizes the regenerated glycerol. An alcoholic nitroglycerol solution reacts rapidly in this sense with an alcoholic sodium hydroxide solution, with development of much heat. The formation of nitrite, however, occurs even on digesting at 40° an aqueous solution of nitroglycerol (1 : 800) with a little sodium hydroxide (0.2 per cent.), the reaction being complete in about ten minutes.

Blood at the temperature of the body acts similarly upon nitroglycerol: the blood becomes chocolate-colored, as is the case when it is exposed to the action of amyl or potassium nitrite. Spectroscopic observation reveals the metahaemoglobin band. Reducing agents reproduce the red color of haemoglobin, as in the case of the nitrites above mentioned. Hence nitroglycerol acts by its conversion into nitrite. (Abst. *Jour. Chem. Soc.* p. 681, *June*, 1885.)

In the course of their researches on the heat-relations of the explosion of gaseous mixtures (*Ann. Chim. Phys.* 4 [6], 66, *Jan.*, 1885), Berthelot and Vieille have been able to obtain the specific heat of the elementary gases at high temperatures. The experimental data were obtained by the combustion of cyanogen mixed with sufficient oxygen to convert it into carbon monoxide and nitrogen—two gases which have sensibly the same specific heat. From the pressure developed in the explosion, the temperature referred to the air thermometer was calculated; and from the total quantity of heat produced, and the temperature, the specific heat (at constant volume) of the resulting gaseous mixture was derived, and hence the specific heat of either of the resulting gases. The results of six experiments of this sort were as follows :

Mixtures.	Pressure developed atm.	Heat evolved.	Temperature.	Specific Heat. Total.	For N_2 and CO.
$C_2N_2 + O_2$	25.11	126,500 cal.	4394°	28.81	9.60
$C_2N_2 + O_2 + 1\frac{1}{2}N_2$	20.67	126,500	4024	31.46	8.39
$C_2N_2 + O_2 + 2N_2$	15.26	126,500	3191	39.67	7.93
$C_2N_2 + O_2 + \frac{79}{21}N_2$	11.78	126,500	2810	45.05	6.67
$C_2N_2 + 2NO$	23.34	169,800	4309	39.39	9.85
$C_2N_2 + 2N_2O$	26.02	168,400	3993	42.17	8.43

It will be noticed that the numbers obtained are closely identical, whether oxygen, nitrogen monoxide or dioxide, is used to effect the combustion; thus, at 4400° the specific heat with oxygen is 9.60 and with nitrogen dioxide 9.85, the ratio of N to CO being 1 : 1 by volume. At 4000°, with oxygen, the specific heat was found to be 8.39, and with nitrogen monoxide 8.43, the ratio of N to CO being 3 : 2 by volume. Moreover, it will be observed that the specific heat increases rapidly with the temperature. This increase may be expressed as a function of the temperature by the empirical formula

$$C = 6.7 + 0.0016\,(T - 2800),$$

giving the following calculated values: at 2800°, 6.7; 3200°, 7.3; 4000°, 8.6, and 4400°, 9.3, the observed numbers being 6.7, 7.9, 8.4 and 9.6 respectively. These numbers may be adopted as expressing, at high temperatures and constant volume, the molecular specific heat of the simple gases N_2, H_2 and O_2, as well as of the compound gas CO, which is closely related to them. It is therefore evident that in passing from 0° to 4500° the mean specific heat of the elementary and simple gases nearly doubles. There is, however, another group of elementary and of compound gases to be considered. Regnault showed that the specific heat of chlorine, bromine and iodine was higher than that of the other elements, being 6.6 at constant volume, instead of 4.8. The remarkable fact is that this specific heat is closely the same as that of the compound gases which are formed with a contraction of one-third in volume, as water, nitrogen monoxide and carbon dioxide. The data were obtained by combining chlorine and hydrogen in presence of an excess of one or the other of these gases; from which it appeared that the weight $\frac{2}{3}$Cl was sensibly equal to that of H_2. The mean specific heat of chlorine at constant volume was found to be at 1800°, nearly three times that of hydrogen, the latter being 5.1, and the former 15.3, nearly. Chlorine comports itself toward oxygen as ozone would do if it were stable and were formed with the evolution of heat.

In a second paper (*loc. cit.* 77), these authors have given the results of similar calculations to determine the mean molecular specific heat of water and of carbon dioxide at high temperatures. The hydrogen was burned either with oxygen alone or with oxygen mixed with nitrogen ; in the latter case, the specific heat of the nitrogen was subtracted. The following data were thus obtained:

Mixture.	T.	Total Specific Heat.	Specific Heat of the N.	Mean Molecular Specific Heat of H_2O between 0° and T°.
H_2+O	3240°	18.12		18.12
$H_2+O+\frac{1}{2}N$	2860	20.52	1.69	18.83
H_2+O+N_2	2543	23.08	6.26	16.82
H_2+O+2N_2	2180	26.93	11.36	15.57
H_2+O+3N_2	1798	32.05	15.21	16.84
H_2+N_2O	3133	25.09	7.20	17.89
$H_2+N_2O+N_2$	2601	30.60	12.70	17.90

The value given in the fifth experiment is not regarded as reliable as the others, since the large amount of inert gas present caused the combustion to be twelve times as slow. It will be observed that here also the specific heat increases with the temperature. The authors represent this increase by the empirical formula

$$C = 16.2 + 0.0019\ (T - 2000).$$

Since the mean specific heat of water-vapor between 130° and 230° is 6.65 at constant volume, it appears that it is more than doubled at 2000°, and tripled at 4000°. On comparing the elementary specific heat of the vapor of water with that of its constituent elements, it appears that the former value is in excess of the latter at 2000° by 7.0, and at 4000° by 5.1. This excess represents a double work—first, that of the molecular disaggregation of the compound gas, and secondly that of its chemical dissociation. The values obtained for carbon dioxide are given as follows:

Mixture.	T.	Total Specific Heat.	Specific Heat of the N.	Specific Heat of the CO_2.
$CO+O$	3334°	20.40		20.40
$CO+O+N$	2840	24.02	3.36	20.66
$CO+O+N_2$	2548	26.69	6.27	20.42
$CO+O+N_5$	1807	37.47	12.67	24.80
$C_2N_2+O_4$	4862	54.00	10.00	22.00
$C_2N_2+O_4+N_2$	4082	64.31	17.50	23.40
$C_2N_2+4N_2O$	3972	86.71	42.70	22.00

The fourth of these results is inaccurate, owing to the extreme slowness of the combustion. The results with CO give a mean value of 20.5 between 0° and 2900°; those with CN give 22.5 between 0° and 4300°. Taking them together, they may be represented by the empirical formula

$$C = 19.1 + 0.0015(T - 2000).$$

This gives for the elementary specific heat of carbon dioxide at 2000°, 19.1; at 3000°, 22.1, and at 4000°, 25.1. The mean specific heat of this gas, therefore, more than triples, and the elementary specific heat quadruples, between 0° and 4300°. (Abst. *Am. Jour. Sci.* **29**, 331; 1885.)

Two difficulties attend the determination of the heat of combustion of carbon and its compounds: one arises from the length of time required, the other from the incompleteness of its oxidation. Berthelot and Vieille have obviated these difficulties by effecting the combustion in oxygen compressed to about seven atmospheres, in a calorimetric bomb; using a weight of combustible such that the oxygen consumed by it does not exceed 30 to 40 per cent. of the whole quantity. The ignition is accomplished by a platinum wire heated to redness by electricity, and is completed in a few seconds, sometimes with the characteristic noise given by an explosion in a closed vessel. The entire operation does not require more than three or four minutes, and is applicable to all substances whose vapor tension at the ordinary temperature is inconsiderable. The completeness of the combustion was verified by an examination of the products. The heat of combustion thus obtained is, of course, the heat at constant volume. For carbon this is the same value as that at constant pressure, since the carbon dioxide formed replaces the oxygen volume for volume. For hydrogen compounds, however, the usual corrections are necessary for the condensation of the water-vapor. When cellulose in the form of cotton was burned in this way, the ash being deducted, one gram gave 4.2 calories; or one equivalent (162 grams) 680.4 calories. The heat of combustion, calculated at constant pressure, the water being in the liquid state, is 681.8 calories. Comparing this value with that of the carbon contained in the cellulose (referred to diamond), 564 calories, it appears that that of the cellulose is in the excess 117.8 calories, or about one-fifth. It follows from this that the hydrates of carbon, so-called, contain an excess of energy above that given by the carbon and water which their decomposition would

furnish. The authors call attention to the fact that this is also true of incompletely burned charcoal, as, for example, the *charbon roux* used in making gunpowder; and hence that the energy of a sample of gunpowder due to the carbon it contains cannot be accurately calculated from its percentage composition. (*Bull. Soc. Ch.* **43** [2] 262, *Mar.*, 1885; Abst. *Am. J. Sci.* **30** [3,] 154; 1885.)

In order to determine the rate of transmission of the explosive wave in solid and liquid explosives, Berthelot (*Compt. rend.* **100,** 314; 1885) detonated them in tubes of lead, tin or Britannia metal, 1–2 mm. in internal diameter and 100 to 200 metres long. The explosives employed were pulverulent or granulated gun-cotton, xyloidin, nitromannitol, nitroglycerol, dynamite and panclastite. The results show that as a rule the rate of propagation of the explosive wave increases with the density of loading, and also, for tubes of the diameters employed, with the diameter of the tube. It also seems to increase with the resistance of the material of which the tube is composed. The detonation shatters the tube in which the explosive is contained, and in this respect the experiments differ from those in which the explosives are gaseous. The results were sensibly the same whether the tubes were bent or straight.

With compressed pulverulent gun-cotton, the mean velocity of the explosive wave is about 5200 m. per second in lead tubes, and about 6000 m. per second in tin tubes. Granulated gun-cotton with a density of 1.1–1.3 gave a velocity of about 5000 m. Xyloidin gave similar results. Nitromannitol gives a still higher velocity, granulated nitromannitol of density 1.9 giving the highest observed velocity, 7686 m. per second. With nitroglycerol in tubes 3 mm. diameter the rate of transmission is lower, and varies between 1078 and 1386 m., according to the conditions. Dynamite in tubes 3 mm. in diameter gave a velocity of 2333–2753 m., and in tubes 6 mm. diameter an average of 2668 m. Panclastite gave results similar to those obtained with gun-cotton.

Berthelot finds (*Compt. rend.* **100,** 1326; 1885) that when gunpowder is dried by stoving, in the usual way, at 60°–65°, a peculiar odor is obtained. This smell is due to the sublimation of sulphur, which also carries with it small quantities of the non-volatile constituents of gunpowder. A quantity of the sublimate condensed and collected on plates of glass had the composition: sulphur 97.84,

potassium nitrate 0.90, charcoal, etc., 1.26 = 100. The vapor tension corresponding to this sublimation is too small to be measured.

Among other substances produced by P. Griess in his researches on the "Diazo Compounds," are azonitromethanebenzoic acid, $COOH.C_6H_4.N_2.CH_2.NO_2$, and azoacetoaceticbenzoic acid, $COOH.C_6H_4.N_2.CHAc.COOH$. The former is obtained by mixing an aqueous solution of pure metadiazobenzoic acid nitrate with a dilute solution of nitromethane in an excess of potash, and after a short time adding hydrochloric acid, when the pure acid is thrown down as a yellowish-red precipitate. It is moderately soluble in boiling alcohol and ether; very sparingly in boiling water; is almost tasteless, and detonates when heated. Its ammoniacal solution gives a deep red-colored precipitate with silver nitrate, and no precipitate with barium chloride.

The second compound is formed by the action of metadiazobenzoic acid sulphate on ethyl acetoacetate. It is almost insoluble in boiling water, readily soluble in hot alcohol, from which it crystallizes in small scales or needles which have a bitter taste. When cautiously heated it melts, and at a higher temperature detonates, leaving a carbonaceous residue. The silver salt forms a bright yellow, amorphous precipitate. (*Berich. Berl. Chem. Ges.* **18**, 960; 1885.)

A. Smolka states (*Monatsch. Chem.* **6**, 198) that when ammonia is added to an aqueous solution containing lead nitrate and mannitol in the proportion of 2 mols. of the former to not less than 1 mol. of the latter, a mannitol lead nitrate having the composition $C_6H_8O_6Pb_4(NO_3)_2$ is precipitated. This substance is sparingly soluble in water and insoluble in alcohol. It detonates when suddenly heated. The nitric acid in the compound is not eliminated by treatment with ammonia. (Abst. *Chem. Soc. Jour., July*, 1885.)

In the study of the "Polyacetylene Compounds," A. Baeyer finds (*Berich. Berl. Chem. Ges.* **18**, 674; 1885) that diacetylenedicarboxylic acid, $COOH.C \vdots C.C \vdots C.COOH$, is obtained by oxidation of the copper compound of ethyl propargylate with an alkaline solution of potassium ferrocyanide. It crystallizes with one mol. H_2O in rhombic tables or needles; it turns brown at 100°, and explodes violently at about 177°. This seems to be the first instance of an explosive substance containing carbon, hydrogen and oxygen only. On

exposure to light, the acid at first assumes a deep rose color; on longer exposure it is converted into a purple-red mass. It is readily soluble in ether, alcohol and chloroform, moderately in water, very sparingly in light petroleum and benzene. With an ammoniacal copper solution, the aqueous solution gives a brownish-red precipitate; with silver nitrate, a white turbidity. In a subsequent paper (*loc. cit.* **18**, 2269; 1885) the author finds that a better yield of the diacetylenedicarboxylic acid is obtained if free propargylic acid is employed for its preparation, instead of the ethyl salt.

The alkaline copper compound yields tetracetyleneolicarboxylic acid, COOH.C ⋮ C.C ⋮ C.C ⋮ C.C ⋮ C.COOH, when oxidized with potassium ferrocyanide. This forms fine, colorless needles which blacken quickly even when protected from light. It is extremely explosive, and yields sebacic acid when reduced.

By warming ammonium diacetylenedicarboxylate with cuprous chloride at 30°, a reddish-violet precipitate of the copper compound of diacetylene is formed, and this, when heated with a concentrated solution of potassium cyanide, yields a gas which has an odor somewhat like dipropargyl, and which, when passed through an ammoniacal solution of cuprous chloride, again yields the reddish-violet precipitate. With an ammoniacal silver solution, it forms a yellow precipitate which is exceedingly explosive, exploding even when rubbed in the wet state between the fingers.

Diiododiacetylene CI ⋮ C.C ⋮ CI is obtained by treating the silver diacetylene compound under water with a solution of iodine in aqueous potassium iodide. It forms colorless crystals and melts at 101°; it smells like iodoform, and when heated in tubes explodes violently with a flash of red light. If kept for some time exposed to the light it is polymerized, forming a brown, crystalline mass which detonates on heating.

Among other "Intermediate Reduction-Products of the Nitroazo Compounds," J. V. Janovsky and L. Erb (*Berich. Berl. Chem. Gesel.* **18**, 1133; 1885) have obtained the trinitroazobenzene by nitrating either mono- or diparanitrazobenzene or azobenzene with fuming nitric acid. It may be crystallized from acetone or alcohol, and is obtained in long sulphur-yellow needles. It melts at 169° to a red fluid, which explodes when heated above its melting-point.

Among the processes used for the production of metallic potassium is that in which an intimate mixture of potassium carbonate and

charcoal is heated in an iron retort. Through the action of the heat a reaction takes place from which carbon monoxide and potassium result. Unfortunately, however, a secondary reaction also occurs, through which a black compound is formed which detonates violently upon the slightest friction. If the potassium be not pure, this compound is readily formed when the metal is exposed to the air, or even when immersed in naphtha.

Liebig was the first to observe (*Ann. Ch. Pharm.* **11**, 182) that metallic potassium united with carbon monoxide. According to Brodie (*Chem. Soc. Qu. J.* **12**, 269; 1859), pure potassium heated to about 80° in carbon monoxide free from air, is at first slowly converted into a dull gray, crystalline substance, ($K_{2n}C_nO_n$); but if the passage of the gas be continued, a more rapid absorption takes place even at a lower temperature, and the gray crystals are converted into a dark red compound $K_nC_nO_n$. This dark red carbonyl may be preserved under mineral naphtha, but is decomposed with extreme violence by water, and even in the dry state sometimes explodes from causes which have not been made out. When anhydrous alcohol is added to this red compound, it is partly dissolved and partly converted into potassium oxide and potassium rhodizonate. Hence the carbonyl may be regarded as a basic potassium rhodizonate.

The black explosive substance formed in the manufacture of potassium appears to consist of one or both of the compounds just described. According to Kühneman (*Jahresb.* 180; 1864), when potassium is intensely heated in carbon monoxide gas, there are formed, first, a gray mixture of potassium oxide and free carbon, which separates as the apparatus cools from a white to a red heat; and secondly, a dark red body, which separates at a temperature below dull redness, both compounds being formed without access of water or moist air. On collecting these separately, the red substance was found to dissolve in water, forming a solution which exhibited all the reactions for potassium rhodizonate. The gray mass was explosive, and Kühneman attributes this either to the heating of the mass through absorption of water, or to the formation of potassium peroxide (from the protoxide present) and its action on the free carbon.

The name rhodizonic appears to have been applied to two different acids, produced under different circumstances from potassium carbonyl. Berzelius and Wöhler noticed that a red substance is produced by the action of water on the black mass formed in the preparation of potassium by Brunner's process. L. Gmelin found

that the aqueous solution of this substance yields potassium croconate when evaporated in contact with the air, and inferred that it contains an acid different from croconic acid. Heller (*Ann. Ch. Pharm.* **24,** 1; 1837) examined this acid more particularly, and gave it the name of rhodizonic acid. It was further examined by Werner (*J. Pr. Chem.* **13,** 404), but the experiments of these chemists did not determine the composition of the acid. Brodie regarded his acid ($C_{10}H_6O_8$) obtained as above described as identical with that previously obtained by Heller and Werner. On the other hand, Will (*Ann. Ch. Pharm.* **118,** 187; 1861), by the analysis of several salts of the acid, obtained in a similar manner to that of Brodie's, but from the impure potassium carbonyl formed in the preparation of the metal, concluded that its composition is $C_{10}H_8O_{12}$ or $C_5H_4O_6$, and this result is confirmed by Lerch (*Ann. Ch. Pharm.* **124,** 20), who has obtained rhodizonic acid in the free state by decomposing the salts of carboxylic acid, $C_{10}H_4O_{10}$, with acids. The acid obtained by Heller and analyzed by Will and Lerch is styled the α-rhodizonic, and that obtained by Brodie the β-rhodizonic acid.

In the experiments of Lerch, he found that if perfectly unaltered potassium carbonyl, to which Brodie assigns the formula $C_nK_nO_n$, be treated with hydrochloric acid, it yields trihydrocarboxylic acid, $C_{10}H_{10}O_{10}$, which crystallizes in white needles. If the carbonyl be first treated with alcohol and then with hydrochloric acid, it yields black needles of dihydrocarboxylic acid, $C_{10}H_8O_{10}$. If the air has had access to the mass before or after the treatment with alcohol, it afterwards yields, with hydrochloric acid, dark, garnet-red crystals of hydrocarboxylic acid, $C_{10}H_6O_{10}$. Lastly, if the mass has been left in contact with the air till it has turned quite red, and it is then treated with hydrochloric acid, a fourth acid is obtained called carboxylic acid, the potassium salts of which have the formulas $C_{10}HK_3O_{10}$ and $C_{10}K_4O_{10}$. On attempting to isolate this acid, rhodizonic acid is obtained.

Nietzké and Benckiser have repeated Lerch's experiments (*Ber. Berl. Chem. Ges.* **18,** 1833; *July,* 1885), and have proved that his trihydrocarboxylic, dihydrocarboxylic and carboxylic acids are identical with the hexaoxybenzene, tetraoxyquinone and dioxydiquinoylbenzene, respectively, already described by them. The carbonyl-potassium was obtained by passing a current of CO, completely dried and freed from oxygen, over potassium heated to melting in a combustion tube. At the close of the experiment the

potassium had gained in weight about 70 per cent.; confirming Brodie's view that one molecule of CO was absorbed for each atom of K. The product was a solid, grayish mass, with here and there patches of a red-brown, green or black color. After cooling, the tube may be filled with strong alcohol without danger of explosion. On treating the crude product with hydrochloric acid, hexaoxybenzene $C_6(OH)_6$ is produced, which proves that the carbonyl-potassium is most probably $C_6(OK)_6$ or potassium-hexaoxybenzene. The former is accompanied, however, by tetraoxyquinone, its first oxidation product, from which it may perhaps be formed during the solution in HCl, by the reducing action of the K still present upon the corresponding potassium compound directly produced: $(CO)_6 + K_4 = C_6(OK)_4O_2$. To ascertain this, the freshly prepared carbonyl-potassium was dissolved in acetic oxide and precipitated by water. The brown precipitate crystallized from glacial acetic acid gave the characteristic hexacetylhexaoxybenzene. The residue after treating the crude product with alcohol is a dark green powder, which turns red in the air, and which, boiled with HCl, dissolves with a brownish-red color. On cooling, the solution deposits stellate groups of steel-blue needles of tetraoxyquinone $C_6(OH)_4O_2$. If the crude product be washed with dilute alcohol, it turns red, and finally produces an ochre-red powder, the so-called rhodizonic acid. This the authors find to be identical with their dioxydichinoylbenzene $C_6(OH)_2O_4$.

The *Jour. Chem. Soc., Jan.*, 1885, p. 69, contains an account of the further researches* of E. Divers and M. Kawakita of the fulminates, under the title "On the Decomposition of Silver Fulminate by Hydrochloric Acid." The fact has already been noted by them that silver fulminate differs from mercury fulminate in yielding much less than the full amount of hydroxyammonium chloride, and in yielding ammonium chloride. Besides, the silver fulminate is energetically attacked by concentrated HCl. If the heating is not checked, the silver chloride produced is at first stained orange, but rapidly loses its color, imparting it to the acid mother-liquor, and it disappears from this during the subsequent evaporation. In addition, there is at first, among the products of the reaction, an unstable, colorless substance which gives an intense wine-red color with $[Fe_2]Cl_6$, either in the acid or neutral solution. Long standing in the cold, or a few

* Proc. U. S. Nav. Inst. **11**, 100; 1885.

minutes' heating, deprives the solution of this power. The only gases liberated by the HCl are CO_2 and HCN. The total nitrogen of the silver fulminate being 9.33 per cent., they obtained

Nitrogen as hydroxyammonium	6.95 per cent.
" " ammonia	1.50
" " hydrogen cyanide	0.18
" unaccounted for	0.70
Total	9.33

It is tolerably certain that some ammonia escapes unmeasured. Though Steiner's experiments have been repeated again, using ether in place of water as a menstruum, no oxalic acid was obtained by decomposing mercury fulminate with hydrogen sulphide.

The results show that no difference exists between the silver and mercury salts as fulminates, what difference they show being caused by the metallic radicals. The same hydrolysis occurs with both; but in the case of the silver salt, in consequence probably of the sharp separation of the AgCl in the solid state, the decomposition generates heat so rapidly that the formic acid and hydroxyammonium chloride change into CO_2 and NH_4Cl, thus:

$$C_2Ag_2N_2O_2 + 4HCl + 4OH_2 = 2CH_2O_2 + 2NH_4OCl + 2AgCl$$
$$\text{and } CH_2O_2 + NH_4OCl = C_2O_2 + NH_4Cl + H_2O.$$

In a paper "On the Constitution of the Fulminates," same journal, p. 77, E. Divers defends the formula $\mathrm{H\overline{CNONC}OH}$, advanced by him,* though he accepts $\mathrm{H\overline{CNOC}(NOH)}$ as equally satisfactory. Yet an argument in favor of the former is that it shows the hydroxyl in union with nitrogenized carbon, and, therefore, as in cyanic acid, markedly basic, while in the latter the hydroxyl of an hydroxylamine derivative is represented not only as basic, but as capable of taking part without difficulty in double decompositions in water and yielding the various bimetallic fulminates, notwithstanding that the hydroxyl of hydroxylamine has been found analogous to "alcoholic" hydroxyl in carbon compounds, its hydrogen being replaceable by organic radicals only, and not by metals, in presence of water, if at all. Schramm's hydroxylamine compounds, containing Ag or Na, may or

* Proc. U. S. Nav. Inst. **11**, 103; 1885.

may not be metaloxyl-derivatives. The Na compound appears unable to exist in water. The radical :N.O.N: has the support of Goldschmidt, who used it in representing the possible constitution of a dioximido-derivative of phenanthraquinone. Divers dissents from the latter part of Armstrong's theory that, in the conversion of alcohol into fulminate, hydroxyethaldehydrol is first formed and then acted on half by hydroxylamine and half by nitrous acid, since these two latter bodies cannot act without mutual destruction, or destruction of each other's derivatives.

Armstrong replies to this that it is possible and probable that the latter bodies may exist side by side if a third body is present with which one or both may enter into reaction, or which tends to exercise a protective influence. Divers' own observations on the action of tin on a mixture of HNO_3 and HCl may be cited in support of this view. Armstrong is inclined to regard $N\Big\langle\begin{matrix}C.OH\\ \cdot\\ C(N.OH)\end{matrix}$ or $\begin{matrix}N.CH\\ \cdot\ \cdot\\ O.C(N.OH)\end{matrix}$ as the most probable formulas for fulminic acid, and that they take into account both the elimination of the two nitrogen-atoms as hydroxylamine and also the formation of bimetallic fulminates; but he does not regard them as final. He also points out that, although the fulminates have hitherto been regarded as "dicarbon" derivatives, on account of their formation from ethyl alcohol, there is no direct evidence to support the view; and it is noteworthy that Divers has always failed to obtain oxalic acid by their hydrolysis.

Dingl. Polyt. Jour. **255**, 337; 1885, describes the following novelties in explosives: For the production of gunpowder containing carbon, J. Nordenfelt and F. A. Memling propose to prepare a carbonaceous substance from cotton, woody fibres or similar substances, by treating them in a loose form with hydrochloric-acid gas, whereby the fibre is converted into a brittle substance.* This is thoroughly mixed with the proper amount of a saturated solution of sulphur in carbon bisulphide in a closed vessel provided with a mechanical agitator. The dry mixture of carbon and sulphur is saturated with an aqueous solution of potassium nitrate, and the water evaporated off at a gentle heat. The powder is then finished according to the usual method.

F. W. Gilles proposes to manufacture explosive compounds by

* Proc. U. S. Nav. Inst. **8**, 309; 1882.

treating molasses with a mixture of nitric and sulphuric acids. He obtains the explosive in two forms, which he calls solid and liquid nitro-molasses. In both cases 380 grams molasses, 1000 grams fuming nitric acid, and 2000 grams concentrated sulphuric acid, are mixed together. The product, when washed first with cold, then with warm water, deposits a precipitate of a gray-yellow or whitish color, and can be used at once as an explosive material. To obtain the liquid explosive, the nitro-molasses is brought to a composition corresponding to 34 parts carbon, 54 parts oxygen and 12 parts hydrogen, nitrogen and salts. When the molasses contains less oxygen and carbon than the above proportion, it is treated in open vessels with lead peroxide and carbon bisulphide, and the mixture is allowed to ferment at a temperature not exceeding 130°. The prepared molasses is then nitrated. When the molasses contains less oxygen than the proportion stated above, it is treated by oxygen gas forced into it under pressure in closed vessels. The fluid nitro-molasses, when heated, slowly boils at between 180° and 200°, and detonates between 220° and 250°, and can be mixed with any absorbent.

In the same journal, **254**, 355; 1884, A. Gacon describes a blasting powder made by mixing 69 parts of potassium or sodium nitrate with 19 parts of sulphur, and adding ash (?) rich in potash or soda to the mixture. It is proposed to obtain this ash by burning dead leaves. 200 grams of tannin dissolved in 8 litres of water are then added to the mixture. One kilo. of this powder is said to blow up 12 to 15 cubic metres of rock. It requires a temperature of 480° for its ignition, and cannot be exploded by concussion, not even when hammered on an anvil. (Abst. *Jour. Chem. Soc.*, *Mar.*, 1885.)

In a preliminary note on the "Theory of Explosions" (*Proc. Camb. Phil. Soc.* **5**, 309; 1885), R. Threlfall has made an attempt to account for some of the anomalous effects observed in explosions by Sir Frederick Abel. In the well-known experiments with detonators composed of various explosives, Abel was led to imagine that the apparent selective efficiency of chosen substances, when applied to explode one another, might be accounted for on an hypothesis of "synchronous vibrations." It was pointed out that this hypothesis can have no possible physical meaning, unless the vibrations be supposed to take place in the ether; and an explanation was sought in the behavior of the products of explosion as regards their motion in

air and in water. For this purpose, the explosives were treated in groups arranged with respect to their supposed time of decomposition, and it was shown that much would depend on the method of "break-up" of the volume of gas set free by the explosion. The various ways in which the energy of an explosion might be transmitted through fluids were enumerated, and some stress was laid on the effects to be expected if the conditions of explosion were such as to lead to the production of vortex rings.

The necessity of clearly defining the meaning of the phrase "violence of explosion" was pointed out, and it was shown that the "violence," as defined by $\frac{\text{increase of volume}}{\text{time of explosion}}$, would not represent the relative destructive effects of explosions in free air. Various experimental methods of treating the question of "break-up" were described, and further communication was reserved pending the result of experiments still in progress.

U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

THE SURVEY OF THE COAST.

By Lieutenant George L. Dyer, U. S. N.

While the officers of the Navy have been watching, with intense interest, the movement to build modern ships and to reorganize the administration of the Navy Department, they have paid little attention to a very important and interesting question which has been the subject of congressional investigation for nearly two years, and is now rapidly nearing a temporary, if not a final, conclusion.

In 1884 Congress appointed a Commission, consisting of three senators and three members, to "consider the present organizations of the .... Coast and Geodetic Survey and the Hydrographic Office of the Navy Department, with a view to secure greater efficiency and economy of administration of the public service in said Bureaus" (p. *1).* This Commission, after sitting for two winters, has now finished taking testimony, and, we are informed by the newspapers, is deliberating what course to pursue.

As many of the officers of the Navy have served in the Coast and Geodetic Survey, and have contributed the greater portion of the work which has continued its existence and sustained its claim to usefulness, and as it is believed that the best interests of the Navy and of the Government will be subserved by its transfer to the Navy Department, it is thought proper to lay before those interested a brief statement of the case as it stands at present.

In order to avoid a confusion of terms, let us notice that the title of this organization is *not* Coast Survey, which naval officers are accustomed to use in speaking of it, and which was its honorable appellation until recently. The act of March 3, 1879 (p. 773), legalized the term *Coast and Geodetic Survey*, thus enabling it to adopt a title indicating functions assumed many years before.

* The pages mentioned refer to the printed "Testimony before a Joint Commission." The italics are generally mine.

In this connection the representatives of the Navy Department have laid great stress on the points that geodesy has nothing to do with a survey of the coast; that geodetic methods applied to land work have absorbed most of the money appropriated for the survey of the coast, and as a result it is not yet surveyed, and no time will be set, without conditions, when the primary survey will be definitely finished.

Commander Bartlett refers to this matter (p. 887) in the following terms:

> The hydrographic work of the Ranger has been of the same character as that done by the naval officers under the direction of the Coast and Geodetic Survey. This is the work which is essential to the construction of a nautical chart. Geodetic refinement of triangulation and elaborate detail of topography have not been attempted, as being entirely foreign to the objects of a nautical survey. Latitudes and longitudes, the variation of the compass, the rise and fall of the tides, have been determined, the positions of the soundings fixed by the aid of triangulation, and such topography delineated as may serve as an aid to navigation.
>
> Mr. Hilgard makes his comments from the standpoint of a geodesist and topographer, to whom a nautical survey is only subordinate and incidental. I speak from the standpoint of a practical navigator and hydrographer, to whom geodesy and topography, at this stage of their development, have only an interest in common with other sciences not materially related to navigation.

The following is a brief outline of the legislative history of the Coast and Geodetic Survey:

In pursuance of the recommendation of President Jefferson (p. 246, Report of Secretary of the Navy, 1882, Vol. I.) to establish a national coast survey "for the purpose of making complete charts of our coast, with adjacent shoals and soundings," Congress passed the act of February 10, 1807, which authorized the survey and made an appropriation for it. This act reads as follows (p. 28): "That the President of the United States shall be, and he is hereby, authorized and requested to cause a survey to be taken of the coasts of the United States in which shall be designated the islands and shoals, with the roads or places of anchorage, within 20 leagues of any part of the shores of the United States; and also the respective courses and distances between the principal capes or headlands, together with such other matters as he may deem proper for completing an accurate chart of every part of the coast within the extent aforesaid."

The work was assigned to the Treasury Department, but, owing to the unsettled condition of affairs at that period, nothing was done

until 1817. By the act of April 14, 1818, which contained the proviso that the survey should be conducted only by naval officers, the Coast Survey was discontinued as a separate organization, and, until 1832, surveys were carried on by officers of the Army and Navy, and, from the results, charts of the most important harbors were made.

By the act of July 10, 1832, Congress revived the organization which was assigned to the Treasury Department, although the act expressly stipulated that the President was authorized to "employ all persons in the land or naval service of the United States." In 1834 it was transferred to the Navy Department, and two years later again transferred to the Treasury Department, where it has since remained.

The question of assignment to the Navy Department being constantly agitated, Congress provided for an examination into, and settlement of, the matter by the act of March 3, 1843. This act provided that the survey should be conducted in accordance with a plan, to be submitted by a board consisting of the Superintendent of the Coast Survey, his two principal assistants, two naval officers, and four from among the principal officers of the corps of Topographical Engineers. A glance at the composition of this board—seven landsmen specialists and two sailors—will show at once that it was arranged to exclude entirely the idea of naval control, and it must have been due to a special interposition of Divine Providence that the consideration of hydrography was admitted at all. It is not to be wondered at, therefore, that an elaborate plan for triangulation and topography was recommended, and that the Treasury was suggested as the proper Department to control the work. The plan received the President's approval, and has since formed the basis upon which the survey has been conducted. No mention of the word geodesy, nor any reference to it whatever, is to be found in this plan. It is clear that a geodetic survey was not contemplated, as the science of geodesy was about as well known in 1843 as now. Picard's geodetic work under the French Academy was completed in 1670, and geodetic surveys have been going on continually ever since.

In regard to this plan Commander Bartlett says (pp. 893–894):

The organization which resulted from this law was bound by the methods prescribed by the board, and, until it had gained experience by actual work, it could not be held responsible for a system which did not attain the results desired within a reasonable time. When, however, it became obvious that the "survey of the coast" would not be completed, it was the imperative duty of this organization to change its methods, either by legislative permission, or by

delaying such portions of the work as did not aid materially in the accomplishment of the special object for which it was created. This was not done. It is only reasonable to assume that its methods never will be changed, except temporarily, under the spur of criticism or investigation, so long as its directors, having little interest relatively in its most important productions, possess only a theoretical or imperfect knowledge of what these charts should represent. This results naturally from a lack of nautical experience.

In 1848, and again in 1849, attempts were made in Congress to transfer the Survey to the Navy Department. In 1850 a resolution of the Senate called on the Secretary of the Navy and on the Secretary of the Treasury to state reasons for and against the transfer. Their replies in 1851 ended the active interference of Congress in the matter for several years, although the agitation for the transfer was continuous to the commencement of the Civil War. After its close, and the subsequent readjustment of affairs, the evident impropriety of leaving this important work under the present management began to assert itself, and finally culminated in the action of Congress already mentioned.

To complete the legislative history of this organization, I will quote from Commander Sigsbee's exhaustive paper in the Report of the Secretary of the Navy for 1882, Vol. I., p. 246:

All acts mentioned in the following list are acts making appropriations for the expenses of the Survey.

The act of March 3, 1853, legalized investigation into the characteristics of the Gulf Stream, involving temperature, deep-sea soundings, and current observations far at sea—a work which should have been done from the outset under cognizance of the Navy Department. The effect of this act was to authorize the Coast Survey to publish "sailing" or off-shore charts.

The act of March 3, 1871, greatly extended the work of the Survey by legalizing the determination of geodetic points in each State of the Union and across the continent. The present title of the Survey—viz. : the *Coast and Geodetic Survey*—was not assumed at once on the passage of this act, but was occasionally heard in 1877, when the transcontinental geodetic work had progressed beyond the stage of probability. This act also legalized a "*development of the dangers of ocean navigation*" between San Diego, Cal., and Panama. Where this work passed the limit of the United States, it should have devolved upon the Navy, according to precedent.

In reference to this act, Superintendent Hilgard says (p. 133, Testimony):

This had underlying the idea of an ultimate trigonometrical survey of the whole area of the country.

The act of March 3, 1875, legalized deep-sea operations throughout the Gulf of Mexico and to an indefinite extent in the Pacific Ocean. A complete deep-sea survey of the Gulf of Mexico followed, lasting for four years. The work was done by naval officers with a Coast Survey vessel. The greater part of the expense, which was for pay of officers and men, came from naval appropriations.

The act of June 20, 1878, legalized the survey of rivers to the head of ship navigation or tidal influences. It also extended the work of the Survey to include deep-sea dredging for animal forms, and widened the field of operations to include a part of the Caribbean Sea. The greater part of the expense was borne by naval appropriations.

The act of March 3, 1879, legalized the title *Coast and Geodetic Survey*, which is borne by the annual report of the Survey for 1878, but not by that for 1877. This act embraces a still wider field of operations for all classes of deep-sea work. Not only is the whole Caribbean Sea included, but also the whole Sargasso Sea in mid-Atlantic Ocean. The Caribbean Sea work was continued as before. A vessel of the Survey was engaged almost exclusively in this class of work for more than seven years. The chief burden of the expense was charged to the naval appropriation.

I have thus fully traced the legislative history of this organization for the purpose of indicating two things—the evidence of unremitting agitation on the part of the Navy to secure the control of what should be a strictly nautical work, and the gradual but certain extension of its operations away from the field which it was especially designed to cover.

In the absence of a continuously definite policy on the part of the Navy Department, the agitation referred to, long since become a tradition of the service, indicates a fundamental error in the composition of the working force, and in the assignment of the administration of this important work.

By reason of this absence of policy, no opposition has been made to the gradual expansion of the jurisdiction of the Coast and Geodetic Survey, until the work on the coast has become entirely subordinated to a great geodetic survey of the interior (p. 869), and the field off the coast is only limited by the shores of those countries which do not permit a stranger to perform their work. Assistant Baker, of the Coast and Geodetic Survey, testifies (p. 633) that "since the creation of the Survey by the act of 1807, the field of the Survey's operations has been gradually extended until it now by law embraces the entire United States and the *waters off the coast to a limit incapable of sharp definition.*"

The organic acts relating to the Coast and Geodetic Survey have

always indicated its manifest purpose. Of late years, however, clauses have been introduced into appropriation bills which, in the absence of a jealous watch on the part of the Navy Department, have gone through Congress unchallenged, and have legalized such works as the system of triangulation along the Appalachians, the transcontinental belt, the furnishing of points in States, and a vast amount of expensive work which no practical seaman or hydrographer will admit to be of value for nautical purposes.

No objection would be made to this were the proper degree of energy and interest taken in that portion of the work which is the support of all the rest—viz.: the hydrography and those littoral operations of triangulation and topography which are essential to it. This has not been the case. The coast of the United States is not yet surveyed, and there are portions of it where any vessel venturing is subject to risks which at this time, nearly eighty years from the commencement of the work, place a degree of culpability on this organization which the maritime community will thoroughly appreciate when it knows the facts.

Commander Bartlett refers to this matter in the following words (pp. 894, 895):

Had the policy thus outlined been adopted, the primary survey of the coast would have been finished years ago, and the responsibility of leaving portions of it unsurveyed, where lives and cargoes must be hazarded, would not have attached to the Coast Survey. This policy would have been adopted had the direction of this work been placed in the hands of those whose duties at times oblige them to venture into unsurveyed waters, and who have an intimate and personal interest in having it done well and quickly.

Most of the money appropriated has gone into land work which is not essential to the production of charts for the use of navigators. Can it be doubted that the sentiment underlying the yearly grant of money to the Coast Survey has been to facilitate the movement of commerce along our coasts and to preserve the lives of seamen?

The triangulation carried on by this organization has been of the most refined and expensive character. The topography has been executed with the utmost elaboration. The character of its work from a scientific standpoint cannot be assailed. But in the meantime the "survey of the coast" has dragged along, and no time is yet set for its definite completion.

For the reason, then, that the accomplishment of its principal object was being delayed—indirectly, perhaps—this organization assumed a very grave responsibility in not changing its methods long ago.

From the standpoint of the sailor who has to venture into unknown waters, how can the expenditure, by this organization, of millions of money for purposes more or less foreign to a coast survey be justified?

In a letter to the Secretary of the Treasury in 1857 (pp. 251, 252, Report of Secretary of the Navy, 1882, Vol. I.), Superintendent Bache, of the Coast Survey, says: "*In determining the scale and mode of executing the coast survey, it should be considered that the work is a temporary one, having a limited object, the surveying of a definite extent of coast; taking all the operations into consideration, the Atlantic sections are more than half done, the Gulf (of Mexico) sections are nearly one-third done, and both can, at the present rate of appropriation, be completed in from ten to twelve years by close economy and thorough efficiency of arrangement.*"

During the Civil War the organization was kept up and received large appropriations; *twenty-seven years*, therefore, after the expression of this opinion by the greatest authority of the Coast Survey, Superintendent Hilgard, of the Coast and Geodetic Survey (p. 137), says: "The work of the Coast Survey proper on the Atlantic and Gulf coasts requires *four* years to make the surveys continuous, at the present [last year's] rate of appropriations"; and (p. 140): "As to the Pacific coast, exclusive of Alaska . . . I estimate the time required to be about *nine* years, at present [last year's] rate of appropriations."

Commander Chester (p. 453) refers to the completion of the primary survey as "many years distant, under the present appropriations of Congress." *Twenty-eight years* after the expression of Bache's opinion, Assistant Colonna testifies (p. 609): "If Congress appropriates with sufficient generosity, and does not bind the Superintendent too rigorously, a practical Superintendent will, in from *three* to *five* years, complete the original surveys on the Atlantic. . . . The surveys of the Pacific coast can be completed in about twelve years with the remodelled force, and funds enough to conduct the work economically." This means, practically, that the survey of the coast will never be completed as long as its unfinished condition constitutes an argument to draw money from Congress for the prosecution of the great trigonometrical survey of the country and its collateral operations.

No really earnest attempt has been made to complete the survey of the coast, and it is believed that no continued and persistent effort will be made as long as the direction of the work is not in the hands of men who have a lively interest in having it well and speedily done. I think this can be fairly concluded from the record of the past; from the fact that, if the coast is not charted rapidly, no particular responsibility attaches to the Coast and Geodetic Survey, under the super-

vision of a department which has no need for coast charts especially; and finally, from the postulate, that men, trained to land work and interested in the operations of geodesy, topography, leveling, etc., unaccustomed to the sea, without nautical instincts and traditions, cannot, in the nature of things, take any great interest, comparatively, in the making of nautical charts.

The first step taken by the Congressional Commission in the present investigation was to call on the National Academy of Sciences for an opinion. This body promptly replied with a report (pp. *1–*10) which must be considered, under the circumstances, as very favorable to the naval side of the question. The withdrawal of the only member of the committee (p. *1) (appointed by the President of the National Academy) whose opinion in the matter could possibly have more weight than that of any educated gentleman, left it composed entirely of scientists whose specialties are about as far removed from questions relating to the needs of seamen as can be well imagined—for the making of charts for purposes of navigation and commerce constitutes the vital principle of both the Coast and Geodetic Survey and the Hydrographic Office, and it cannot be ignored in any consideration of the relations of these bureaus.

This report naturally advocates the claims of science. It goes so far as to recommend that all scientific branches of the Government be put in one department, in order to give scientific investigations greater unity and success. It might be expected that, recognizing the work of the Hydrographic Office as scientific, the National Academy would think it advisable to group it with the other bureaus. It does not, however, as will be seen by the following. After a very thorough account of the present administration of the Hydrographic Office, the committee says (p. *6): "This work of the Hydrographic Office is evidently of great value and importance to our commercial and business interests, and must save many vessels from wreck and many lives from destruction.

"While this work [that of the Hydrographic Office] is scientific work, your committee is not prepared to recommend that it be detached in any way from the control of the Navy Department." This recommendation, from a body whose tendencies would be almost irresistibly in the other direction, must be considered conclusive.

But the Academy goes further. It states (p. *3): "The hydrographic surveys of the coasts of Europe appear in every country to be the work of the Naval Establishment," and traces the history of the

Coast and Geodetic Survey, showing the gradual advance into fields not originally contemplated. Then follows a practical recommendation to transfer to the Navy Department the direction of the survey of the coast after it has been once accomplished (p. *6):

> Nor can they recommend that the hydrographic work of the Coast Survey, for over forty years conducted so satisfactorily under the civil control of the Coast Survey, be separated from that organization *before the original survey shall be completed. After that is done, perhaps the work of re-sounding, of re-examining may without injury to the service be committed to the control of the Navy Department.* . . . While, therefore, your committee are not prepared at the present time to recommend the proposed consolidation, we do not conceive that Congress should adopt measures looking to the separation in perpetuity of the two branches under consideration. The policy of the Coast Survey should, we conceive, be directed towards the completion at the earliest possible date of the survey of our coast line; its main operations will thereafter be confined principally to the interior, and then the policy of consolidating its hydrography with the work of the Naval Hydrographic Office will be open for consideration.

This conclusion was reached from the considerations contained in a preceding paragraph, which is as follows (p. *6):

> The reasons for the consolidation of these two works under the Navy Department have been urged with force by the Secretary of the Navy in his last two annual reports (1882 and 1883). But there are also cogent reasons on the other side of this question. The Coast Survey was specially organized to secure the harmonious co-operation of civilians, officers of the Navy and officers of the Army, each in his own department and yet in a single, well co-ordinated work. No scientific department of the Government has worked more successfully through the forty years in which this organization has been in operation. Each of the three branches thus harmoniously co-operating has received the benefit of the skill and professional experience of the other.

These are the "cogent reasons" advanced for the recommendation already quoted. It is very evident that the committee made no examination into the details of this important matter. The grave and artless assumption that this is a fact which those interested will accept, with proper deference to the character of the body which utters it, recalls the credulous dignity of Sir Joseph Porter, K. C. B. *There have been no Army officers attached to the Survey since the commencement of the Civil War.* Where is there co-ordination between the remaining bodies, naval officers and civilians, in that most important and expensive branch, the field-work of the Survey? Just how much exists is known to every officer who has been on duty in the Coast Survey, and who has had to climb about in all sorts of places to cut

in his own signals, or who has had to search for triangulation points long since obliterated, or who has had to take the sheets of the topographers and change the scale for his own hydrographic work. This same absurd pretension appears throughout the testimony of the witnesses on the part of the Coast and Geodetic Survey. The harmonious co-operation of the three branches! What a picture of brotherly love in this modern Utopia! Here we see the different elements of soldierly pride and dignity, naval dash and pertinacity, combined and controlled, harmonized and united, under the beneficent guidance of civil attainments and tact. So much perfection must needs seek to change the aspect of Nature so as to make it conform to its own condition. Hence, we find our old notions of geography entirely out of date. Rude violence is done to our imperfect conception of the seashore, and, under the new nomenclature introduced by the Coast and Geodetic Survey, the seaman has the advantage—does he fully appreciate it?—of knowing that the Atlantic coast is not alone

> "The gutter'd rocks, the congregated sands,
> Traitors ensteep'd to clog the guiltless keel,"

but that it extends far out into the Western prairies, and is only limited by the claim of the topographers of the Pacific slope that their coast shall have a similar extension to the eastward. The Rocky Mountains have become significant features of the seashore landscape, and the grand old Father of Waters, no longer entitled to the proud distinction of being an interior and mighty river, is reduced to the category of seaside runs. Regard for an instant this naïve definition of the coast by Superintendent Hilgard (p. *30): "In fact, the terms of Section 4681 (Revised Statutes, law of 1807, already quoted) require no straining to be applied to the ascertainment of the distance and direction between Cape Cod and Cape Mendocino or between Sandy Hook and the Golden Gate."

An inspection of the charts of the Coast Survey will show, further, how much weight to place on this claim of co-ordination. The triangulation appears to have been done at one time, the topography at another, and the hydrography at still another; and finally, the assertion that "no scientific department of the Government has worked more successfully," etc., can be dismissed as idle, in view of the fact that the coast is not charted yet, although money enough has been spent to do it several times over. If this is a measure of the success of our scientific departments, we certainly overrate their importance.

The first witness before the Commission on the subject of most interest to us was Superintendent Hilgard. He defends the transcontinental triangulation on the ground that it will "bring into harmony the measurements along the Atlantic and the Pacific coasts" (p. 51).

I have thought of this sentence a great deal in the endeavor to bring it "into harmony" with common sense, but am unable to see anything more in it than a wretched play upon words which, surely, cannot be attributed to the author of such a serious assertion.

He then enunciates certain "scientific results" and "practical advantages" which relate to land surveys and have no reference to the survey proper of the coast. On p. 149 Mr. Hilgard offers the following summary in opposition to the proposed transfer:

1st. The present system, perfected nearly forty years ago, has proved thoroughly efficient, economical, and satisfactory to the country. It is wise to hold fast to that which has been proved to be good.

2d. It affords the Navy all the advantages that can be legitimately claimed. It employs as many of the officers in service afloat as can be advantageously used in hydrography. The employment of a large number, in the event of a transfer, would result in training naval officers to be geodesists, topographers, chiefs of technical bureaus, and in withdrawing their interests and habits from the naval service proper.

3d. The efficiency of the service would suffer by the loss of ambition and emulation, which exist at present in a high degree, but which find no stimulus in a service where no positions of responsibility and direction are open to civil experts, however great their attainments and devotion to the public service.

Look at the lamentable condition of this organization to-day: a prey to informers, subjected to investigations which have thrown no credit on it, in charge of a department clerk without any special knowledge of its technical necessities, and its operations condemned by eminent men both in and out of the Navy.

This is what the President thinks of it (see Annual Message, December, 1885):

This service has never been regulated by anything but the most indefinite legal enactments and the most unsatisfactory rules. It was many years ago sanctioned, apparently for a purpose regarded as temporary, and related to a survey of our coast. Having gained a place in the appropriations made by Congress, it has gradually taken to itself powers and objects not contemplated in its creation, and extended its operations until it sadly needs legislative attention.

So far as a further survey of our coast is concerned, there seems to be a

propriety in transferring that work to the Navy Department. The other duties now in charge of this establishment, if they cannot be profitably attached to some existing department or other bureau, should be prosecuted under a law exactly defining their scope and purpose, and with a careful discrimination between the scientific inquiries which may properly be assumed by the Government and those which should be undertaken by State authority or by individual enterprise.

It is hoped that the report of the Congressional Committee heretofore appointed to investigate this and other like matters will aid in the accomplishment of proper legislation on this subject.

How does this state of affairs agree with the assertion that "the present system has proved thoroughly efficient, economical and satisfactory to the country"? It may be said that this was not the result of the system, but of the inefficiency of the men who controlled it. I contend it was the natural result of a system which provided for a *necessary* work by placing it in the hands of men who speedily made it *entirely* subordinate to other work, of doubtful necessity, in which they, as landsmen, naturally took more interest. Being a technical work, it has had no supervision by the Treasury Department, as it would have had under the Navy Department, where most of the Secretary's staff is composed of men who, from experience, have a keen appreciation of the value of a chart, and comprehend the necessity of having the coast surveyed.

Let us examine still further this claim to efficiency. In the first place, it is necessary to revert to the fact already stated, and which is admitted by all the witnesses for the Coast Survey, that the *coast is not yet surveyed*, although it was commenced nearly 80 years ago, and there has been spent for this purpose the sum of $24,593,143 (see Report of Captain G. M. Wheeler, U. S. Engineers, upon the Third International Geographical Congress and Exhibition at Venice, Italy, 1881, p. 532).

A fair conclusion can be reached, also, by regarding the character of its publications with a view to the purposes for which they are intended. Director Powell, of the Geological Survey (p. 166), states:

The Coast Survey has made charts of the coast. These charts are maps of a peculiar character. The water areas are hydrographic maps, necessary for mariners, but, in order to subserve this purpose properly, certain land areas of the coast are included. On these land areas it is necessary that the salient landmarks should be plotted, as guides to mariners, and so far the work is a proper chart for mariners. But much additional material is placed on these charts. To a large extent the charts are cadastral maps on which are plotted

estates. On some of the maps relief topography also is introduced to a greater or less extent, but usually this is lacking, and when introduced it is subordinate to the cadastral purposes of the chart. . . . The Coast Survey has not made a cadastral survey by surveying properties and establishing marks on the ground, but it has made cadastral maps.

Again (p. 168):

The Coast Survey has constructed charts of the coast. These maps are very elaborate, and represent a vast system of cultural or artificial details; they are, therefore, very expensive; *they are also difficult to understand.*

Again (pp. 184–185):

They [the Coast and Geodetic Survey] have not made a cadastral map by looking up titles and plotting the boundaries of properties described in titles; but they have marked out the essential features of the estates, such as the houses, the fields, the private roads, and various matters of that nature which belong to what I have defined as a cadastral map. But where a chart is constructed in such a manner as to a large extent to neglect the natural characteristics by placing upon the chart the boundaries and improvements of estates, I have called that a cadastral map, even when it is not based upon a cadastral survey—that is, a survey intended to mark the boundary-lines of estates upon the ground.

Again (pp. 197–198):

The Coast and Geodetic Survey constructs maps, or, more properly speaking, charts of the coast. These charts represent in part water areas and in part land areas. On the water areas are represented the soundings and important features of the sea and river bottoms. Other things also are represented, such as buoys, lights, etc. The land areas represented are in part islands and in part mainland. On these land areas are represented the landmarks which are used by mariners in the navigation of the waters. So far, they are strictly coast charts, useful in navigation. In surveying the land areas, the Coast Survey does something more, by extending the map-work back a short distance into the country, varying from half a mile to five miles. This additional work is of a peculiar character. All streams, large and small, that run in or through this margin of land are plotted upon maps; all coast marshes are plotted; all rocky ledges and points are indicated, and, to some extent, hills are represented. In addition to this, many artificial features are plotted, such as city, town and village plats, country roads, farms, fields, houses, and many other artificial or cultural details. The surveys made for these cultural details do not include complete cadastral surveys, but only sufficient cadastral surveying to make it possible to correctly plot such items upon the maps.

I am unable to state any useful purpose which this cadastral or artificial element in the coast charts subserves; first, because it is not executed so as to form a complete cadastral map; second, *because these artificial topographic features are ephemeral; that is, this culture changes from year to year in such*

a manner that the charts speedily become misleading. In illustration of this fact I may state that one of the Commissioners of the Massachusetts Survey informs me that he has lately examined certain charts made in Massachusetts on this plan, and he discovers that in the areas coming under his eye, fifty per cent. of the houses placed upon the chart twenty years ago have disappeared, or been removed to new sites ; that, in addition to this, a large number of new houses have been erected which do not appear on the old charts, and that the confusion arising from these two causes renders the charts almost unintelligible. He also informs me that the same confusion arises from the delineation of fences, but to a greater extent, and that a similar confusion arises through the delineation of minor public or private roads, but not to so great an extent.

Again (p. 204):

The Coast Survey endeavors to give its topographic determinations with a degree of refinement commensurate with its geodetic work, and to this end employs refined methods of instrumentation and calculation, and uses direct measurements and computations in nearly all stages of its work, to the minutest details—proceeding as if upon the theory that a cadastral survey would result therefrom, and that the boundaries of estates would ultimately be established thereby; for these more exact measurements cannot be represented upon the map.

Again (p. 206):

There is no substantial difference in the accuracy of the charts of the Coast Survey and the topographic maps of the Geological Survey *as maps.* As distances are computed in the office, the more refined methods of the Coast Survey show greater accuracy in the computations of the topographers ; but this greater accuracy has no effect whatever upon the maps themselves. *If we measure a distance of* 40 *miles by a method the probable error of which is* 10 *feet, and by another method the probable error of which is* 10 *inches, the computations in the office will exhibit that difference; but that difference cannot be shown in the construction of the map itself,* and, in fact, a much greater error than that would be inappreciable upon the map.

Again (pp. 383–384):

The first question of importance in a plan for a topographic survey relates to the facts which should be represented upon the map. For all purposes for which a topographic map is made, except the functions of a military map, the natural features of the country are of prime importance. The natural features, therefore, should be represented. Of the artificial features there are two classes: Those which may be included under the term public culture, relating to the sites of towns and cities, and of highways of all classes—canals, railroads and wagon-roads; all of these should be put upon the map. There is another class of artificial features, which relate to private properties. *These are houses, fields, orchards, etc., and, as they relate to private property or estates, they may*

be called cadastral features. These should not be placed upon general topographic maps for the following reasons: First, they are so minute that they cannot be properly represented without enormously increasing the scales. Second, their delineation upon the map obscures the conventional characters used to represent natural and public topography, and, to the extent that they are introduced, the more important features are obscured: the map becomes more complex and less easily interpreted. There is yet another potent reason for their exclusion. When a map has been constructed, it must be maintained, to be of permanent value. The natural features remain, the cultural features are changeable, and those cultural features which have been denominated "cadastral" are the most changeable. If they are represented upon the topographic map, constant revision becomes necessary, and this can be accomplished only at great cost. For all these reasons it is manifest that cadastral topography should not be placed upon a general topographic map.

Again (p. 638):

I think I have clearly shown that the topographic system adopted, because of the amount of cultural features presented thereon, would speedily become obsolete, so that every few years a resurvey would become necessary; and the maintenance of such a map (of the whole U. S.) would cost many millions of dollars annually.

Commander Bartlett (p. 81) says:

I am having constant complaints from merchants and coasters with regard to the inaccuracy of coast charts.

And again (p. 892):

Errors in the charts reported by letter formed but a small portion of the whole number. Scarcely a day passed that errors or omissions were not reported unofficially by means of the telephone, and on one occasion I took with me to the Coast Survey Office more than 100 charts of different localities every one of which contained errors. These charts had been supplied to the Hydrographic Office as correct and ready for issue to our ships of war.

Again (p. 893):

In order to secure proper charts for the use of ships of war, the Hydrographer is held responsible for their accuracy. My experience with the Coast Survey charts has been such that I do not *dare* to issue them to our ships until they have been carefully examined. In case of disaster no responsibility could attach to the Coast Survey under the Treasury Department. It is therefore a necessity to keep corrected files.

Again (p. 895) Commander Bartlett says:

To prove still further that the real purpose of this organization has been either ignored or misunderstood by its directors, the charts that have been published have not satisfied the maritime community. Had this been the case, how could

it have been possible for a private individual like Eldridge to adapt these charts to the needs of seamen, and sell the reproductions at much higher prices than the Coast Survey demands for the originals? All foreign nations of importance reproduce Coast Survey charts, leaving off much of the topography and changing the skeleton or projection from the polyconic to that of Mercator.

There are many projections, but Mercator's is the only one familiar to all seamen, and upon which, with the exception of the Coast Survey, the nautical charts of all seafaring nations are based. Its advantages over the polyconic for general purposes are undeniable, and the efforts of the Coast Survey to educate seamen to accept a projection, simply because it shows topographical features with less distortion than that usually recognized as best for a sea-chart, have resulted in failure. The reasons for and against these two projections can be readily presented, and the unpopularity of the polyconic projection cannot be assigned to prejudice.

Naval officers almost universally dislike these charts on account of the polyconic projection and the use of both feet and fathoms to indicate depths of water in close proximity. One uniform system of showing depths is less confusing, and is universally in use elsewhere.

Again, the preparation of the Coast Pilot has been unnecessarily delayed, and only recently has it been finished as far as Cape Hatteras. The Navy Department has been obliged to buy Eldridge's Coast Pilot for issue to the ships of war. This is a publication, by a private individual, which covers the whole Atlantic and Gulf coasts. The Coast Survey publication, as far as it goes, is open to the same criticism of useless and unnecessary elaboration.

The following extract from a letter from Rear Admiral C. H. Davis, dated April 15, 1864, to Professor Hilgard, will be pertinent in this place. A copy of this letter has been submitted to the Commission, and will probably appear in the volume of testimony:

You cannot be surprised that I should insist, as a practical navigator, upon the use of Mercator's projection. The Mercator projection belongs to the sea, just as the modern compass does, and I may say that it finds its proper and peculiar value only on the ocean; so, also, the compass and Mercator's projection belong to each other, and neither of them is, as an instrument of navigation, complete without the other. Thus, it is only on the sea that people direct their way by the compass, both for the moment and in prospect; it is only on the sea that they have occasion to project a compass course as a guide, and it is only on Mercator's chart that such a course or rhumb-line can be projected and inspected without calculation. All this is familiar to you, as it is to me, in principle; but it is not so in practice; and it is precisely this difference in practice which prompts me to speak so freely. I think I do not go too far in saying that your not using the Mercator projection will exclude your charts from use in the merchant service, if it does not in the men-of-war of the country. If you retain the conical projection, you will be the only office in the world in which such a principle of stereography is employed for nautical charts. In truth, the

principle is defective, as applied in this case, and the Coast Survey has never hitherto admitted anything defective in principle, however insignificant in value.

The following extract from a letter from Lieutenant H. H. Barroll, on duty at the Branch Hydrographic Office, Philadelphia, is deserving of great weight in the consideration of this matter. This letter has also been submitted to the Commission, and will probably be printed with the testimony:

In this connection I would state that, having had occasion to consult with hundreds of captains of vessels, it is almost invariably their opinion that the topography of Coast Survey charts—extending for miles inland and delineating stables, barns and roads, never visible from even the mastheads of vessels—has gone as far inland as the needs of charts for maritime purposes demand.

The only practical importance of such extended topography upon marine maps would be probably to assist hostile littoral expeditions. I can readily see that such charts of foreign countries would be of great advantage to our Navy; but a chart's practical utility to merchant vessels ceases at the point at which also ceases the possible view from the vessel's deck. Large mountains, or prominent objects suitable for ranges, can be topographed upon the chart, and their heights given in figures, as in the present hydrographic system, or in those charts published by all other hydrographic offices. The general opinion of seafaring men is that there is absolutely no need on marine charts of the extensive and expensive topography of cultural peculiarities of a country, which peculiarities never meet their eyes.

Disregarding the careful work with which these outside objects have been depicted by both topographer and engraver, they generally regard the chart in the light of a chart with chromo attached. With the merchant mariner, assuredly, that chart is best which embodies in a given space the most peculiarities of the land and water-surface with which he has to deal, *and the least of that portion with which he has nothing to do.*

Coast Survey Chart No. 124 contains the entire topography of that portion of the Cape May peninsula within the limits of the chart. There is a mass of minutely executed topography, extending across the entire peninsula, wherein even out-houses are represented, although so completely surrounded by pine woods as to utterly preclude the possibility of any seaman viewing the said out-houses, except by making an especial journey by land for that purpose. At the same time, the shoals off the point of Cape May (same chart) have changed so much since surveyed that there is no dependence to be put upon Coast Survey Chart No. 124, so far as these shoals are concerned. Of what avail is the topographed position of each farmhouse to the mariner who cannot dare to trust the hydrography in order to get near enough to see the farm house?

Speaking of this chart, one of the captains in our merchant marine remarked to me three days ago: "I see there is four feet of water here" (indicating on the

north shoal off Cape May). "*I found that nearer five feet out of water, at dead low water.*" This difference of nine feet in soundings is of more importance to the merchant skipper than the topography of the whole line of Coast Survey work from Pittsburgh to Atlanta. The best proof of the preference of the merchant marine for Hydrographic or Coast Survey charts would be in the number of each sold to merchant captains.

Owing to the Hydrographic Office being restricted to foreign countries, the only charts published by both offices covering comparatively the same ground are Coast Survey Chart A, and Hydrographic Office Chart No. 942, the latter being apparently a reproduction of the U. S. Coast Survey chart, with the superfluous soundings and unnecessary topography omitted.

To satisfy myself that the ground I have taken in regard to the preference of the merchant marine for less interior detail was correct, I submitted the following letter and questions to the firm of Riggs & Brother, the leading chart dealers in this city:

[Copy.]

PHILADELPHIA, *January* 28, 1886.

MR. RICHARD RIGGS.

Dear Sir:—Will you kindly answer for me the following questions in relation to the sale of your charts? . . . . . .

1. Do you find the polyconic projection of Coast Survey Chart A, satisfactory to the majority of merchant marine officers, or do they prefer the Mercator projection of Hydrographic Chart No. 942, which covers the same ground?

2. Do you think the additional topography employed by the Coast Survey upon their charts is of material assistance to the merchant captain? By this I mean such features as do not appear in views.

3. What has been the sale of charts Coast Survey A, as compared with Hydrographic Chart No. 942 (which covers the same ground), since the date of the issue of the latter chart?

4. Do you find any objections to hydrographic charts published by the U. S. Hydrographic Office from surveys by U. S. Naval officers entirely—such, for example, as Hydrographic Chart No. 189, Harbor of Hakodadi, Japan, recently issued?

Yours very truly,

[Signed] HENRY H. BARROLL,
Lieutenant U. S. Navy.

[Copy.]

PHILADELPHIA, *January* 29, 1886.

LIEUTENANT HENRY H. BARROLL, U. S. N.

Dear Sir:—In answer to your request, we are pleased to submit the following information as received from purchasers of Hydrographic and Coast Survey charts.

In answer to your 1st and 3d we find that the Mercator projection of Chart No. 942, Hydrographic Office, is preferred nine times out of ten to that of the polyconic projection of Coast Survey Chart A.

Question 2. The additional topography upon the Coast Survey charts is not particularly desired by merchant captains, as all they desire is what appears in view, or adjacent to the coast.

Question 4. Chart No. 189, published by the Hydrographic Office, is desirable, and special charts of that character are what are generally desired by purchasers.

We are respecfully yours,

[Signed] RIGGS & BROTHER.

It would then appear that from the most severe test—from the number of persons stating preference by purchasing the chart itself—that in the *single* case where the superfluous topography can be left upon the maker's hands, the merchant marine prefer in the proportion of 9 to 1 to leave this topography and, for its price, to purchase another chart of some other quarter of the globe. . . . Coast Survey charts are acknowledged by all who understand them to be accurately constructed, and are well engraved and printed, but they *do* contain a large percentage of matter entirely useless to a person purchasing a marine map.

It is rather calculated to excite remark among sailors that summer resorts in the North, and winter resorts in the South—such places as the upper Penobscot and Mount Desert in Maine, and St. John and Indian River, Florida—have been topographed with painful exactness as to detail, while a portion of *our outer* Florida coast is untouched, and there is no proper scale Coast Survey chart of Cape Hatteras Shoals, the most dangerous point to sailors on the American continent.

Will a close examination of a Coast and Geodetic Survey chart sustain the claim that "there are no better in the world" (p. 886)? It has been considered somewhat in the light of an act of disloyalty to attempt to throw any discredit on the operations of the Survey. The mere sight of the Coast and Geodetic Survey seal is usually a sufficient argument to silence any caviler who ventures to express his opinion that a sailor needs a chart for navigation, and not a land map. As I have looked into the matter very carefully, and have had my opinion sustained by many naval officers of experience, as well as by many officers of the merchant marine, I may be excused, perhaps, for having the temerity to assert that the Coast Survey charts are *not* the best in the world. The consideration of the capabilities of the officers of the merchant marine should enter largely into the determination of what charts should represent; and I think no one will deny that a chart should have depicted on it only such matter as is of use to a sailor in navigating his ship, and that this matter should be correctly, clearly, and simply delineated.

Take, for example, Coast Survey Chart D, one of the latest issued. The polyconic projection renders it impossible to use parallel rulers, and the course cannot be projected as on Mercator's projection. Compare this with Chart No. 944, recently issued by the Hydrographic Office. Another good example is Coast Survey Chart No. 369—New York Harbor. This shows soundings so numerous as to bewilder the eye, and the topography is so elaborate, and depicts objects of such a minute character, as to confuse and obscure the delineation of those objects which might be of use as landmarks.

The chart loses much of its value, as a chart, above the entrance to the Narrows on account of the scale, but makes it up, perhaps, as a suburban guide. How much more useful to have put into a larger-scale chart of the East River some of the money spent in the topography of truck-gardens on Staten and Long Islands!

Secretary Chandler says (p. 63):

> The chart of New York Harbor, for example, contains a minute topographical map of the whole interior of Staten Island, showing roads, farms, fences and inclosures. This work, of an exceedingly expensive character, goes to swell the cost of the sailing chart without being of the slightest value to the mariner; indeed, it is a question whether such a chart would be of value to anybody, except, perhaps, to an invading army.

Where is the navigator who, going into New York Harbor after a night of anxious watching outside, will not condemn such an elaborate picture and wish for a simpler delineation which will give him the depth of water and a few conspicuous landmarks for the verification of his position? An unfortunate thumb-mark might cause a serious doubt to arise as to whether certain figures meant feet or fathoms, and I can well conceive that the perplexities of the chart might almost destroy its usefulness. There is no doubt about the accuracy of the data; there ought not to be: it has cost enough to get them; there is no doubt about the high character of the work of the naval officers; but they have contributed their intelligence and labor to aid in the production of beautiful pictures, which are more appropriate for the library and the gallery than for practical uses on board ship. The naval officers have done the hydrography, but have had no share in the question as to how it shall be used. Is not this the reasonable and inevitable sequence of a purely scientific administration of the Coast Survey?

Now let us turn to another phase of the question. The cost of the preparation (*i. e.*, drafting and engraving) of the plate of New York Harbor (Coast Survey Chart No. 369), up to the present time, is $9909. A very careful and detailed estimate made in the Hydrographic Office shows that the drafting and engraving of the hydrography ought not to have cost more than $2000. This leaves nearly $8000 for making the picture. When we consider the cost of getting the data—that is, the expense of making the survey—the figures presented by Captain Wheeler in his report, already quoted, are suggestive enough. A careful measurement of the surveyed portions of New York Harbor, as shown on Coast Survey Chart No. 369, gives 263

square miles of topography and 299 square miles of hydrography. The topography, at $333 per square mile (Wheeler, p. 533), has cost the Government $87,579, "increased by the expense of the initial astronomic work, measured bases and preliminary work." What is to be thought of such figures, particularly in view of the fact that much of the topography is out of date and wrong to-day? A note on the chart says that most of the topography was done between 1855 and 1862. According to Superintendent Hilgard (p. 155): "The country is building up on the shores of Long Island Sound, for instance, so that you would not recognize the shore from the old maps."

If this elaborate topography is made for purposes of "defense," as provided by the plan of 1843, is it not a questionable policy to publish it to the world? Being of no value to the mariner, would it not be just as serviceable for reference stored away in the archives of some Government bureau?

Is it not time that some one who can speak with authority should let Congress and the people know how much is being paid for our charts, so that this lavish expenditure for unnecessary work shall be stopped and the money put into a practical survey of the coast? The general view of the subject here presented may cast some doubt on the assertion that "the present system . . . has proved thoroughly efficient, economical and satisfactory to the country."

In regard to the conservative conclusion of Superintendent Hilgard that "it is wise to hold fast to that which has proved to be good," after what has been already said it will be only necessary to quote Mr. Chandler (p. 68): "I am not content to stand still in government. I want to see government improve practically, and if the argument 'let well enough alone' is to prevail, we shall get no improvement."

The second proposition (p. 149)—that "it [the present system] affords to the Navy all the advantages that can be legitimately claimed"—does not seem to me, from the standpoint of a naval officer, to have any weight at all. While serving in the Coast and Geodetic Survey the *status* of a naval officer is about the same as if he were on leave. The experience gained by him would be the same, in whatever department a Coast Survey might be placed, as it will always be a valuable nursery for the officers and men; but as far as the *standing* of an officer goes, he might just as well spend his time doing nothing. He goes into the Coast Survey and is forgotten until the detail clerk at the department indicates that his time has expired. His experience

is most valuable; his work, mitigated by breaks due to the large assignments of appropriations to shore work, is laborious; but where is his record? The Hydrographic Inspector can have some influence, perhaps, in determining his assignment to duty, but that is the end of it. As far as the Navy Department is concerned, he is just where he was when he left it to make his visit to another department of the Government. So much for the individual. How about the Navy in general? Very few officers realize what confusion exists in the minds generally of very intelligent people in regard to the relations of the Navy and the Coast and Geodetic Survey. I have had good opportunities of observing this, and my experience leads me to the conclusion that the general sentiment is that the Navy has nothing to do with the Coast and Geodetic Survey. At all events, this body is pre-eminent, and the Navy is relegated to such a subordinate part in its operations that it is never heard of. When we consider that the survey of the coast is probably the most important public work this Government has ever undertaken, and that the Navy has contributed by far the most important part of it, it seems almost incomprehensible to me that the Navy has not demanded its share of the public credit, and insisted upon it so unanimously and so forcibly that its proper influence in this heterogeneous partnership should appear to all men.

In the testimony of Assistant Boutelle in answer to "What has the Coast and Geodetic Survey done for science?" (p. 870), the omnivorous character of this organization is well exemplified. Although he mentions individuals by name and does not stint his commendation of their work, the effect of the whole paper is to absorb the efforts of all contributing agencies, and we unconsciously yield to the influence of this draught of self-adulation and are no longer shocked that so small a body should swallow the earth, as it practically claims to have done (see Assistant Baker's testimony, before quoted).

This all-pervading and overwhelming influence of the civil staff of the Coast and Geodetic Survey is boldly enunciated in Superintendent Hilgard's third and last proposition (p. 149): "The efficiency of the *service* would suffer by the loss of ambition and emulation . . . . which find no stimulus in a service where no positions of responsibility and direction are open to civil experts." This, being freely rendered, means that the "service" depends entirely on the civil assistants, who will not work unless they continue just as they are, and, therefore, we cannot expect any more good charts.

The second part of Superintendent Hilgard's statement—that "a transfer would result in training naval officers to be geodesists, topographers," etc.—is sufficiently answered by Commander Bartlett (p. 894):

The primary survey of the Atlantic and Gulf coasts should have been finished years ago.

A survey for the purpose of commerce and navigation should be accurate—that is, such a degree of accuracy, and no greater, should be obtained as can be represented on the charts. The hydrography should be based on a triangulation including measured bases, and the topography should embrace such natural and artificial objects as will serve as aids to navigation. In general, astronomic observations for latitude, longitude, the variation of the compass, and tidal observations, complete the list of operations necessary to secure the data for a nautical chart.

The triangulation should not be of geodetic refinement, as that necessitates great expense without securing adequate results. It is not desirable to determine the position of a point within a fraction of an inch when a dot on a chart of the largest scale covers more than one hundred inches. A small error may be magnified when carried through a long distance, but this cannot develop if the triangulation is properly checked.

The topography inside of the shore-line should embrace only a few prominent objects. In these days, when artificial aids to navigation, such as buoys and beacons, are so numerous, very little topography is necessary for the seaman's use. The fact that elaborate detail of topography is unnecessary will be fully understood when it is considered that vessels go into our harbors about as freely at night as during the day. In view of this fact, also, it will be seen that the expenditure of much time and money in getting the exact outline of the shore within limits which cannot be shown on a sheet of paper, is hardly defensible when such outlay could have been employed to obtain soundings of dangerous parts of the coast yet uncharted.

Director Powell also says (p. 168):

In complex scientific mensuration the several kinds of measurement used in the several parts of a great work should be correlated with each other; one part should not be more refined than another, and none of the parts should be more refined than is necessary for the purpose to be subserved. The reason for this is very simple. Every additional degree of refinement in measurements is attained only by additional expense of time and costly apparatus, and in general the expense increases at a ratio higher than the refinement. The principle which I have thus enunciated is the great economic law of scientific research.

The work of the naval officers attached to the Ranger, the Pinta, and the Coast Survey vessels working in Alaska, is perfectly satisfactory, although they are *not* geodesists or topographers by profession.

The following testimony in regard to the competency of naval officers will be edifying to those who have had experience in surveying. Referring to the interior geodetic work, Superintendent Hilgard says: " We take some competent gentleman of the locality, such as a college professor approved by the Governor " (p. 55). This gives us an insight of the methods by which the Coast Survey has gained so many respectable backers, and also contrasts remarkably with statements on p. 151:

Q. Am I right in understanding you to say that bright young men recently graduated at the Naval Academy would be able to learn in one season how to do geodetic work?

A. No, sir, not the geodetic work.

Q. Explain why they would not be able to do the geodetic work.

A. They have to learn it. They could in one season familiarize themselves in observing, when working alongside of an experienced chief. They could make a selection of signals, and they could aid him in observing; but experience requires a long time, say five years.

There is more interesting testimony on the point that a college professor can leave his class-room and, without experience, suddenly develop into an observer of sufficient merit to have his work accepted and made part of the refined geodetic survey, while a naval officer cannot learn to do the work in less than five years.

Assistant Mitchell (p. 545) says:

Q. Suppose the entire work of the Survey were to be transferred to the Navy Department . . . . would the men who are now engaged in the work be still required?

A. They would be absolutely required, unless an interval of several years is to be given to teaching the naval officers the land work.

Q. Will not the naval officer easily learn to execute the hydrography and topography together? Or what is the impediment in the way of a naval officer's making both those surveys? They seem to be closely and intimately connected.

A. They are closely and intimately connected, but they use entirely different instruments. The plane table is the instrument used by the operator on shore, and he requires a training of four or five years. It is apparently a simple instrument, but it requires great skill in the operator, and our best topographers have had twenty years' experience. The naval officers can learn it just as any other young men can, but they cannot do the work without a long training.

Assistant Colonna (p. 770) states in regard to this matter:

Q. These professors who are employed as acting assistants have—some of them—never had any training in making observations in the field before their employment, have they?

A. It is very true that they never have had.

Q. Is their work generally accepted or rejected by the Coast Survey?

A. I have never known it to be rejected.

Q. Are the young men educated in the Naval Academy sufficiently educated to enable them to make good assistants in the Coast Survey?

A. It takes a training of five or six years before I consider a man proficient, and he needs then to pursue the calling with singleness of purpose, devoting his whole time and energy to it.

Again (p. 772):

Q. I desire to get a little clearer idea as to the extent to which the work of these professors, when they act as assistants, is accepted.

A. The whole of it is accepted for what it is worth. I do not know of any of it having been rejected.

Q. Do you mean to say that other assistants of the Coast Survey go to work and change the points that they (the professors) have located in the field?

A. No, sir; . . . . but they do not send their records into the office in good shape. A man will make a certain record and give no explanation of it, and we have to write to find out what it means; but when we get an explanation, it is perfectly plain, generally.

Q. But is theirs (the work of the professors) accepted and taken as part of the work?

A. Yes, sir.

Q. And not done over again?

A. No, sir.

There is more of the same sort of contradictory nonsense in regard to this subject. As a matter of fact, the Coast and Geodetic Survey has been glad to obtain the services and accept the work of any gentleman whose influence might be of value in any emergency. It would be quite unnecessary to consume time and space in explaining to naval officers, and particularly to those who have been engaged in surveying, the absurd nature of this pretension that it would require five years for a naval officer to learn to do the shore work necessary for a nautical survey; for this is what lies at the bottom of these assertions, that the transfer should not be made because naval officers cannot learn to do a necessary part of the work in the time usually allotted to them for this service. It must be very evident, even to those unacquainted with the details of surveying, that this position is untenable, in view of the fact that college professors can do the work sufficiently well without previous experience.

What special quality is this, beyond the reach of other men, which lies within the faculties of the assistants of the Coast and Geodetic Survey and their occasional companions, the college professors?

What a monstrous claim to excellence which insists that the sole power of manipulating surveying instruments rests with one class of men to the exclusion of all others! Even the work of the topographers of the Geological Survey (p. 620), and that of the engineers of the Army (p. 630), is sneered at, and the attempt is made to force the conclusion that the survey of the coast must remain in the hands of this superior set of mortals, that a large force of naval officers and men and more than $250,000 of the naval appropriation must continue to be farmed out annually to the Coast and Geodetic Survey, because, forsooth! a naval officer can never learn to handle those magical instruments of precision, the theodolite and plane table.

The remainder of the testimony of Supt. Hilgard relates to the undertaking of the Coast Survey to make a general trigonometric survey of the whole country and its collateral operations, the compilation of a general map of the United States, the error in distances due to the deflection of the plumb-line, the relations of the Coast and Geodetic Survey with the Geological Survey, which is also carrying on a topographical survey of the United States, and various details of coast work which are not strictly pertinent to the object of this paper.

There has been no denial on the part of the witnesses of the Coast and Geodetic Survey that the naval officers do all the hydrographic work. That they do it is affirmed, however, and it is generally admitted that they should continue to do it, although under greater restrictions than heretofore. Assistant Colonna, who must be considered as the mouthpiece of the Survey, being its executive officer and official representative before the Commission, makes certain statements which will give the officers of the Navy an idea of how their services are regarded (p. 550):

I think you gentlemen [the Commission] must be quite surfeited in considering our relation with the Navy and hydrographic work, etc. I have noticed several times in the newspapers, of late, statements that the Coast Survey costs the Navy two hundred and odd thousand dollars a year for soundings, which is very true; and, moreover, it takes one-third of our appropriation for purposes of Coast Survey field work, which makes altogether about $337,900 for the fiscal year 1885 that has been spent simply for hydrography. That expenditure, for results obtained, is outrageous. Yet it has been used as an argument to show that the hydrographic work of the Coast Survey should be transferred entirely to the Navy Department, because they say the Navy pays for nearly all this work. I do not wish to be understood as arguing that the hydrographic work should be taken away from Navy officers working in the Coast Survey. There are reasons why the Navy should naturally do that work, but under proper

restrictions, and just where they are now doing it—that is, in the Coast and Geodetic Survey.

Again (p. 553):

I just simply rebel at the idea, when I consider the work accomplished and its cost by the civil force, and compare it with the work done and cost of it by the Navy, of saying that it is a matter of economy to have this work done by the Navy. Put it in the hands of the Navy, in its entirety or in part, and they will bring up a similar set of civilians to that we have now. The only thing gained will be that the experienced surveyor and the blue-jacket will have arrived at the same level, to be commanded by an ensign instead of the men who have experience in this business that civil officers of the Coast Survey have.

Again (p. 554):

We have to equip and man these vessels and get them to sea, which is all right; but when they come in, say for all winter, they should be put in charge of shipkeeper, laid up, as it is called, which costs about $50 per month. Such is always done with vessels commanded by a civilian. If, however, it is a naval officer who commands, she is laid up as a boarding-house, with cooks, stewards and servants, and even very nearly a full complement, all told, on board, and she is kept in full commission until she is needed to go out again. I will cite you the steamer Patterson, built for Alaska work. That vessel came into the harbor of San Francisco on October 5, and she lies there now with a full crew aboard, numbering thirty-nine persons, at an expense of over $1588 per month, with not a single thing for these people to do in prospect for six months to come. It is true it comes out of the Navy appropriation, but it comes out of the Treasury, after all, and it is charged against the Coast Survey by naval officers desirous of a change, as a valid reason why such change should be made. No such expenses of laying up as those of the Patterson, Hassler, and other vessels, would ever be permitted a civil party, and it is unjust to charge such expenditures, made in accordance with naval customs and regulations, to a civil bureau where they are tolerated, but not approved.

Again (p. 555):

The men commanding these vessels are educated for and worthy to defend their country's honor on the high seas; but when they come to us they are not surveyors, and they leave about the time they become proficient. The post-graduate course we give them is a valuable one, but it ought not to cost so much.

The opinion of so competent an authority as Superintendent Thorn must not be omitted (p. 613): "Expensive work in hydrography is the price of the proper tuition of a small annual detachment of young naval officers in local geography."

Mr. Colonna says (p. 556):

Q. If I understand you, then, Mr. Colonna, you would have in the naval appropriation bill the appropriation for seamen, and so on, in the Coast Survey a separate item ?

A. I would have that a separate item and attached to the appropriation bill for the Coast Survey, and make the Superintendent of the Coast Survey responsible for its expenditure, so that when officers were detailed from the Navy and went into the Coast Survey they would only receive what they are absolutely furnished by the Coast Survey, and on a civil basis. I would absolutely put the thing on a civil basis if I wanted to get the work performed at the most reasonable price and in the most excellent manner.

Q. In other words, instead of enlisting sailors you would hire men ?

A. I would hire sailors just as they are hired in the merchant marine. The best sailors we have are in the merchant marine. You can rarely get a really number one sailor to go aboard of a man-of-war, because of the discipline there ; because he sees positively no chance on earth for advancement ; his way is blocked ; he can possibly get to be a petty officer, but cannot get any further. An American does not like that plan. And you will rarely find a first-class New England sailor on a man-of-war.

Q. How much of a saving can be made by adopting your plan ?

A. I think that $100,000 would be saved to the Government annually if, instead of allowing $256,000 to be spent from the naval appropriation annually, the Coast Survey appropriation were increased $156,000, and the whole appropriation be put in manageable shape under the hand of a strong Superintendent. It would not admit of any scientific humbuggery, but lots of good, honest, hard work could be done, and results adequate to the expenditure be obtained. The Coast and Geodetic Survey could be well managed with a gross appropriation of $725,000, which is the estimate of this year, plus $156,000 for hydrography.

On page 594 Assistant Colonna gives a comparison between the "cost of the Coast and Geodetic Survey schooner Earnest, commanded by a Lieutenant in the Navy, doing hydrographic work on Hood's Canal and vicinity, southwest of Admiralty Inlet, in Washington Territory, and that of the Yukon, commanded by civil assistants of the Coast Survey, working in similar smooth waters to the Earnest" (see pp. 593–595):

For the naval-officered Coast Survey vessel for fifteen months.........	$8,889 44
And for the civil-officered Coast Survey vessel for fifteen months....	4,525 97
A difference of.........	$4,363 47
Now, counting all salaries and expenses, we have :	
For the naval-officered vessel, fifteen months' expenses..................	$13,173 25
For the civil-officered vessel, fifteen months' expenses..................	9,668 00
Naval in excess of civil, for fifteen months	$3,505 25
Deduct this amount from salary and allowance for civil officers for fifteen months	5,142 85
And we find that it only lacks, in order to leave the naval officer at home on full pay and allowance, an additional saving in this case of	$1,637 60

· And if you disregard the fact of the charge of the salary of one assistant in the Yukon party, which was accidental only, and arose from the fact that he had sustained injuries in the prosecution of his duty which prevented him from performing the active field work himself, it will be found that it would have been cheaper to have left the naval officer on shore with full pay and turned the work of the Earnest over to a civilian by about $108, and this, too, carrying the naval officers at full pay. If he had been left at home on waiting orders, there would have been a saving to the Treasury of $1017, they being carried at minimum.

An examination of these tables from another point of view shows the following:

The only expenses under control of chiefs of party are

	Navy.	C. Survey.		
Current expenses....................	$643 72	$1063 19		
Repairs of vessel....................	235 16	387 58		
Shipkeeping..........	....	392 00		
	$878 88	$1842 77		
		878 88		
Balance in favor of navy...........	....	....	$963 89	

Expenses under control of Superintendent of Coast Survey and Hydrographic Inspector:

	Navy saves.	C. S. loses.		
By detaching officer when laid up, leaving him for other duty.......	$679 00			
More officers when laid up than when at work.........	....	$833 00		
		679 00		
Balance in favor of navy............	....	....	$1512 00	
	Navy saves.	C. S. saves.		
Discharging men when laid up....	$2390 76	$3888 99		
		2390 76		
Balance in favor of C. S............	....	....	$1498 23	
Balance for navy..........	....	....	....	$ 13 77
Add balance (table preceding). ..	....	....	....	963 89
Total balance in favor of navy....	....	....	....	$977 66

Again (pp. 597-598) we find the following strange doctrine with regard to the authority of the Superintendent of the Coast Survey:

Q. Let me finish my question. We will start again. This abuse that you have spoken of, arising from the fact that the naval officers in each of these Coast Survey vessels keep under pay, when the vessels are laid up during the winter, a larger number of employés than there is any necessity for, has been going on all the time. You mean to say that this is just a fair sample of what has been done for years under the Coast Survey, do you not?

A. That is not something for which the naval officers or the Superintendent of the Coast Survey are responsible.

Q. But, I ask, is it not a fair example of what has been done?

A. It has been going on for years and years, and is a part of the naval system which naval officers brought to the Survey with them and have kept up.

Q. That naval system has been under the control of the Superintendent of the Coast Survey, has it not?

A. No, sir.

Q. Has not the Superintendent of the Coast Survey had the right all the time to order and control the vessels of the Coast Survey, and to say how many employés there should be?

A. No, sir; he has not had that right in fact.

Q. Has he had it in law, according to the law and regulations?

A. No, sir. Custom is our only law and regulation that I know of on this point, and this is a naval custom. The Navy brought it to us and have kept it with us through their own officers. This is a fault of the naval system, to which it is proposed to transfer work and not war. The naval man-of-war goes under commission, and she stays under commission until put out of commission. The naval officer comes to the Coast Survey, and has from the time of its first organization; but they have brought the naval system into the Coast Survey with them. It is that system that keeps the vessel in commission, and it is that system—good for war vessels, bad for working vessels—that I would advise to be broken under the present organization, rather than have it perpetuated by transferring the hydrography to the Navy Department. It is not the naval officer who is to blame who is on duty in the Coast Survey, nor is it the Superintendent of the Coast Survey. It is the system that he brings from his man-of-war and applies to a working vessel that is at fault. That same officer would work in the same way if you transferred the Coast Survey to the Naval Department. If it goes there, you will never see that this fault exists. The Navy will never see it. It will be swallowed up in their general system. This is absolutely the last view that you can have of naval methods of work, if the transfer is made. You will never know what the work does cost, and it will continue to be run just exactly in the way I have described, for no one will have any interest in breaking it up. There will be a thousand and one excuses and ways of explaining the expenses. I am well aware that I am encountering an enemy to our time-honored institution who is on the alert, well intrenched, and with an almost impenetrable picket line, along which a tremendous social and political influence keeps an untiring watch.

To show the consistency of this witness, see p. 605: "The Superintendent of the Coast Survey has it in his power, whenever he chooses to exercise that authority, to call the Inspector to account about any matter."

Again (pp. 614, 615, 616):

Q. You have stated that, in your judgment, the hydrographic work under the present system is performed with reasonable satisfaction?

A. Yes, sir.

Q. But you assume that there is an undue expenditure of $100,000?

A. Yes, sir.

Q. You have also stated your opinion to be that in case of the transfer to the Navy Department the expense would not be diminished?

A. I think in that event it would increase.

Q. In what way, in your judgment, can that evil be remedied?

A. By keeping it right in the Coast Survey—with the organization just as it is; by putting a strong man as Superintendent of the Coast Survey, who will say, when work is completed for the season, "Lay up your vessel and dispense with your crews"; and let him have the authorities back him up in what he directs.

Q. That, in your judgment, can be readily effected without any change in the law?

A. Without any change in law at all.

Q. Simply by properly administering the law?

A. That is all it needs; no changes needed at all in law.

Q. Should there be no change in reference to the detail of naval officers, and putting them under the charge of the Coast Survey for the performance of this work?

A. I see no necessity for further law to aid in details. The detail could be made just as exact as it is now.

Q. How do you propose to correct this undue expenditure of money in vessels under the charge of naval officers?

A. Just when the time comes to lay the vessel up, the Superintendent should say, "Put one man on board of her, or two men if necessary," instead of allowing an Inspector to say it; and he should see that it was done, allowing the naval officers to go home or elsewhere and wait until the vessel was ready to go to work, and then put them on board again.

Q. You do not mean to say that the Superintendent has not a sufficient authority, if he sees fit to exercise it?

A. He has sufficient power to do it, if he sees fit to exercise that power, I think; but custom has made an unwritten law for us.

Q. But I understand that the naval officers in charge of those vessels in commission, as in the Navy, were not subject to the Superintendent of the Coast Survey?

A. They are subject to the Superintendent, but in the matter of not laying up vessels when unemployed is a naval custom that has been brought into the Sur-

vey which I think would not be allowed, custom or no custom, to the extent it is, if the Superintendent of the Coast Survey felt that he was strong enough, and exercised his authority as he should.

Q. It is a question of administration, then?

A. It is a question of administration.

Q. The system of employing naval officers to co-operate with civilians, as they do now in the Coast Survey, has been in vogue all the way from 1843 down to the present time, has it not, with the exception of the period of the war and a short time afterwards?

A. Yes, sir; I think it is a very good arrangement, too.

Q. If the law is administered as now proposed under present, temporary organization, and so continued in the permanent organization of the Coast Survey that may be effected, will this saving of $100,000 result?

A. Yes, sir, I think so; if a strong man is put at the head of affairs in the Coast Survey, it certainly will;—a man who does his duty, and does it right; strongly supported by the authorities.

Q. The trouble, then, in reference to undue expense has arisen from the inefficient administration?

A. Yes, sir; in my opinion, it has.

Q. When did that inefficient administration begin?

A. In a greater or less degree it has been running in the Coast Survey ever since I knew anything about it, but it has reached its maximum in the last three years.

Q. How long have you been in the Coast Survey?

A. Fifteen years.

Q. Is this custom of which you speak—of keeping those vessels in commission all the year round—a new custom?

A. As old as the system itself, I think.

Q. That is, dating back as far as 1843?

A. To the best of my knowledge and belief.

Q. So this inefficient administration is not a new thing?

A. No, sir; not a new thing.

. . . .

Q. . . . . I propound a question as to whether this expense resulted on account of inefficiency on the part of the Superintendent of the Coast Survey. Does or does not that inefficiency by which the excees of $100,000 is expended relate to his omission to enforce his authority in regard to the expenditures made on vessels in commission under the Navy Department?

A. That is just exactly what it relates to.

I have called attention to these disconnected statements of Assistant Colonna in order to show to the officers of the Navy just how much credit they are getting for their work from the Coast and Geodetic Survey officials. As a matter of fact, the officers have always been a necessary evil, for a geodetic survey would never have stood on its own merits before. It is possible that the people may not be ready

yet to indulge in such a luxury. The various statements made by Assistant Colonna were so completely refuted by Lieutenant-Commander Brownson, the present Hydrographic Inspector, that I have transcribed his exceedingly interesting testimony almost entirely (pp. 879–887):

The total appropriation for the Coast Survey for the year ending June, 1885 was $518,000. Now, of this amount there was appropriated for all field work—geodesy, furnishing points for State surveys, topography, hydrography, etc., and everything of that kind—$154,000. Of this amount there was expended by naval parties for hydrography, $37,387—for outfit, coal, etc. I think that was the question you were trying to get at a few moments ago, and I call your attention to the small amount of it expended for hydrography for the fiscal year ending June 30, 1885.

Q. That did not include the pay of the Navy officers?

A. No, sir. The field work, or work of all parties engaged in collecting data away from the office for the purposes of the Coast Survey, cost $154,000, but only $37,387 of it was expended under the Navy.

Q. Does that include also the fitting out of the Coast Survey vessels?

A. That includes everything except the repairs of the vessel. I am referring now only to the appropriation of the $154,000. . . . There was an additional appropriation for repairs of vessels, including new boilers for the Hassler (and I would also add that the Bache received new boilers out of this appropriation), of $42,000. The whole amount of pay and rations, officers and men, serving on the Navy vessels employed in the Survey was $239,033.34.

Q. That is for naval officers?

A. For pay and rations of all naval officers and all enlisted men serving on the Coast Survey.

Q. Does that include what is known as extra allowance? There are, we are told, certain extra allowances made to officers on the Coast Survey.

A. There was during one year an allowance varying from $15 to $30 per month for subsistence. That ran through a period of a little less than one year.

Q. That was not in 1885?

A. Yes, it ran into 1885; but it was stopped by Mr. Thorn, so that practically that allowance had only been paid for one year since 1860. The law always admitted of it, but it never was paid, except as stated.

Q. Except in 1885?

A. Except in 1885, up to the time the payment was stopped.

Q. In your statement of the $37,387 for hydrography did you also include that additional expenditure?

A. Yes, sir, I did.

Q. Then that additional expenditure is probably not included in Mr. Colonna's statement of $256,000. I wanted to see whether or not that difference was not accounted for in the shape of extra allowances.

A. He refers to the pay and rations of the Navy. This makes the total cost of hydrography, including pay and rations to officers, $318,420.34, making

the total cost of the Coast Survey for that year $836,420.34. Mr. Colonna claims that this $239,033.34 is very much in excess of what it should be. In other words, he claims that the administration of the Navy in the Survey is bad as regards the handling of crews and the laying up of vessels, and cites, among other cases, the case of the Patterson, a vessel which was constructed entirely for work in Alaska. This vessel works where she is cut off from all machine-shops, and all places from which she could recruit her crew. It is a matter of prime necessity that she should have an intelligent and experienced set of men. If a man turns out bad or unsuitable in any way, they cannot get rid of him up there. They cannot replace him, because there is no one up there to enlist.

It is not thought expedient, in these exceptional parties on the Pacific coast, to discharge men while waiting for work in the spring which will begin probably about the 20th of March, or between that and the 1st of April. It is as difficult to replace our boat-steerers and leadsmen in the hydrographic parties as the observers. At times it is more difficult, and in running a range in a strong tide-way it is necessary to have experienced men.

There is another point, too, about the discharge of these men, and that is that the service of many of them is practically continuous. I have known men in the Survey who have been there twelve years. Those men, of course, know everything about the work. They have become themselves almost hydrographers by means of their long acquaintance with the work, and to discharge them would certainly be very unjust. If this is "Navy methods," then we pursue it, notwithstanding the slur that has been cast at it by Mr. Colonna.

Mr. Colonna submitted to you also a table, in which he showed the vessels at present at work in the Survey, and the number of officers and men that there were aboard of them. This table is made out, it is supposed, for November 30, and this date is one between the working seasons. He gives not only the officers, but also the men. Where he obtained the data for this table I cannot tell. For that date I do not have it myself. The quarterly returns are the only ones that will show it, and the last one was on the first of October. The table is very misleading as regards the number of officers and men. The Eagre, the Drift, the Palinurus, the Ready, and the Daisy, five vessels used by naval parties during the summer, had 67 men on board when at work. In accordance with instructions which had been issued, that force was reduced when they were laid up to 27 men, which they have now. The chiefs of parties were ordered to select such men as were of the most use to the Survey, including in each case carpenters and machinists. The officer in charge of these vessels is supposed during the winter to keep them in proper condition, and the service of these men will enable him to have the vessels ready for work next April without submitting an estimate for repairs. In other words, these men are, by their work on the vessels, not only saving money to the Government in this way, but they are a nucleus of experienced men which, with the addition of the working complement of seamen in the spring, will form a good hydrographic party.

As an instance of the work done by these men, the commanding officer of

the Bache submitted, a short time ago, an estimate for $650 for new decks for that vessel. That was, however, more money than we could spare for that purpose. I sent him directions to take these five carpenters in addition to his own, buy the material, and lay the decks. The cost of that deck was $171.34 as against $650, which was the bid of a reliable shipbuilding firm. Their men would have been paid $2.50 to $3 a day, while we had the work done by our own men.

Q. On the regular pay-roll as seamen?

A. Yes. It was a great saving in that way.

The table also shows, I notice, that Mr. Colonna has put down certain vessels which had been used by civil parties as "laid up all right," while the Arago appears as last used by a naval party, and "laid up over a year," the natural inference being that there was something wrong in the case of the latter vessel. As a matter of fact, she has been laid up just as the others have been, with one or two men on board. The table is misleading, as already shown, by the statement that we had 67 men on certain vessels, when in reality there were only 27.

Then, again, just as soon as the civil parties get through with their vessels, the care of them is immediately turned over to the Navy, and we have to stand the expense of looking out for those vessels during the winter. When a topographical party wants the vessel, the man aboard is discharged from the Navy rolls and taken up on the civil force.

Also, Mr. Colonna does not bring to your attention the fact that these men whom we keep aboard the vessels in New York—to which he seems to object—are not only repairing the ships that are going to be used for the hydrographic work, but are also putting in order those that will be used by the civil parties.

Q. For what?

A. For topography and current work; and all that goes against the Navy pay—$239,000.

Q. You regard these expenditures made for hydrography during the fiscal year 1885 as made with reasonable economy and prudence under the charge of naval officers?

A. Undoubtedly. They could resort to a cheese-paring process of economy that would cut it down. I do not mean to say that it could not be reduced, but I say the reduction would be small, and there would be corresponding loss of work.

Q. And reduction at the expense of efficiency?

A. Yes.

Then Mr. Colonna comes down to the number of vessels in the Survey, and he says there are twenty-five; and he wants to sell some of them. We have twenty-five vessels in the Coast Survey, of which number ten are steamers. There are three schooners unfit for use, and I shall recommend that they be sold at the first opportunity. Another, the Daisy, is a tender to a vessel; still, she is included in this list of steamers. The number of vessels, when thus reduced, will not be greater than will be required for the hydrographic parties and civil

parties together. *Mr. Colonna wants to retain those for the civil parties, but he does not say much about retaining those which are engaged in the hydrography, which, as I understand it, has been the mainstay of the service since it was organized. Or, in other words, it furnishes the information which is of the most importance to the navigator.*

Q. The original object of the Coast Survey organization was to survey the coast?

A. That was the original object.

Here is another answer of Mr. Colonna [referring to page 557 of the testimony], which hardly seems to merit a reply, where he refers to the Navy:

To the number of men that may be employed on Coast Survey work there is, you will observe, no stated limit. They get as many vessels as they can, and put as many officers and men on them as they can, and make it as easy for themselves as they can; that is not work, nor is it business; but it is what you may expect and what will go on without check if this is handed over to the Navy. The Navy is as fine a set of fighters as the sun ever shone on, but they are not surveyors, as a rule, in a practical sense.

It is a well-known fact among the officers of the Navy, and the civil assistants also, with the exception of Mr. Colonna, that the Navy officers in the Coast Survey are a very hard-working set of men. I have undertaken to get some facts, and have written to the chiefs of parties during the past summer to give me their standing orders regarding hours of work. I find that the boats left the ships at from 7 to 7.30 A. M., returning at from 5 to 6 P. M.

I say that practically the amount of work done by hydrographic parties is limited only by daylight and the endurance of the men.

Officers accept this duty for two reasons. Those who lead parties accept it because they get command of a ship. The ensigns and junior officers accept the duty because they have more responsibility thrown on their shoulders, get better quarters, and are more independent. The training that officers get on the Coast Survey is the very best that we have—not alone as hydrographers, but as naval officers, as increasing their efficiency as sea officers.

Q. As a rule they are not averse to this work?

A. No, sir. We have little difficulty in getting all the officers that we want. Many are very glad to get on that work instead of serving on ships of war; but they do more work in the Coast Survey than they do on board a man-of-war. They do this simply because they get the increased responsibility and better quarters.

In a previous statement Mr. Colonna says they are not surveyors, and something also about it taking three years to become a hydrographer. The naval officers come into the Coast Survey very well equipped for the work. They have an extended knowledge of the use of instruments, of the handling of boats, and, what is about as important, experience in the handling of men. Any officer of two or three years' experience after leaving the naval school will make a good hydrographer at the end of a month or six weeks. He will get the aid of all the little tricks that have been learned as the result of experience from the other people on board of the surveying vessel. It would hardly do to fit out a hydrographic party with all new men, because their records would not be

so complete or systematic. And then, again, they would have no one to impart to them the many technical wrinkles which come as the result of years of experience. They are very quickly acquired, however, these little arts to which I refer, that tend to systematize and shorten the work.

Q. How about topography on shore? What is your experience or observation in that respect?

A. I think there is no doubt that they can do it. As regards the topography, I think they would not resort to the same degree of refinement that the assistants reach after their use of the plane table for years. But they can do all the topography that is necessary for a chart.

Q. How about the triangulation on shore?

A. They can do all that is necessary; the points are already furnished us.

Q. But as to those points where the work is not already complete?

A. They can carry it on. Lieutenant Clover, in command of the Patterson, has been doing this work in Alaska—triangulation, topography and hydrography—with a naval party. There was one civil assistant sent by the Superintendent to do the astronomical work, but the party was complete without him, and the commanding officer did not want him.

Q. Do you think you could organize out of the hydrographic service a party that could complete the shore work as far as it is left incomplete by the Coast Survey?

A. Without any doubt, sir.

Q. And do it as well as they have done their work?

A. Yes, as regards chart work. I do not say they would get the same refinement in topography that these gentlemen do, but I say as regards the shore line and all topographical features necessary to a navigator they can do it.

Q. Do you think they could do the triangulation without any difficulty?

A. All that is left to be done.

Q. That is, they could fill out the Coast Survey work?

A. Yes.

Q. You think they could take up the work right where it is?

A. Yes; they are doing that work in Alaska now.

Q. You think this could be done entirely by the hydrographic parties of the Navy Department without reference to the Coast Survey?

A. I do. From Mr. Colonna's strictures regarding naval officers as hydrographers, one would suppose that he had had a very extended experience in this branch of surveying, but the records of the office show that his experience is very limited. I think he has done less hydrographic work than a young naval officer would do in two months on the Survey. I speak of this because he has not had the experience—according to his own testimony, where he said that the study of three years was necessary to make a hydrographer—to entitle his opinion to any value.

Q. You say you are responsible for and in control of all the hydrography that is being done by the Coast Survey Bureau?

A. No, sir; if I conveyed that idea, I certainly did not mean to. I intended

to say that I was responsible for the naval administration in the Survey as regards the crews, laying up of vessels, etc.

Q. Do you control the hydrography proper now?

A. Under the direction of the Superintendent, I do. As he is new to the office, it is controlled by the advice of the Hydrographic Inspector.

Q. While Mr. Hilgard was there, and before Mr. Thorn came in, to what extent did Superintendent Hilgard direct and control you? Did he adopt, generally, your suggestions, and were you practically in control?

A. I did not serve under him. I did not relieve Commander Chester until after he was deposed. But the usual method of procedure was for the Hydrographic Inspector to submit a scheme of the work he considered advisable, which the Superintendent either approved, modified, or rejected, as the case might be.

Q. You do not know, then, except from hearsay?

A. I can simply say that it was usual for him to adopt the most of the Inspector's suggestions. *It depended on the appropriations, and in the main they were so divided that the civil parties got what they wanted and the remainder went to the naval parties.* The work of the naval parties depended on how much they received.

The following extract from a letter of Lieut.-Com. Brownson is a part of the record:

Those portions of this testimony wherein reference is made to the Navy and to naval methods consist in great part of assertions which betray ignorance or show lack of full comprehension of the subject. Some of these assertions cannot be allowed to pass unchallenged; but the impression they have produced is probably not as great as to make necessary a lengthy and wearisome exhibit in order to show their fallacy.

The burden of certain parts of this testimony which call for brief notice is to the effect that wasteful methods are practised in carrying on the hydrographic work of the Coast Survey under Navy officers, in consequence of which this work costs annually $100,000 more than it should. This sum would appear to have been named at random; but, once stated, it is repeated as if it had been determined by some logical examination of the question. According to brief explanatory remarks occurring several times, but always in the most general terms, this saving is to be effected by the discharge of crews when vessels are unemployed.

This proposition shows lack of careful consideration, as may be readily shown by quoting a few figures from Mr. Colonna's testimony and from the papers submitted by him. A statement incorporated in his testimony gives the average annual cost of the hydrographic work of the Coast Survey done by naval parties during a period of ten years as follows:

Pay and rations, naval force, from Navy appropriation	$242,000
Party expenses, naval force, from Coast and Geodetic Survey appropriation	55,000
Repairs, etc., from Coast and Geodetic Survey appropriation	33,000
Total	$330,000

Thus the average annual cost of this hydrographic work is stated to be $330,000, of which it is asserted that $100,000 might be saved.

The last two items of the statement are actual working expenses, covering repairs, outfit, and supplies of material used in carrying on the work. *When parties are laid up, it is generally because of the small amount apportioned from the Coast and Geodetic Survey appropriation for these expenses.* True economy would demand a larger amount, that, possessing the plant already, the work might go on continuously. No criticism appears to be made of present expenditures under these items ; certainly none could be justly made.

The saving is to be effected, then, in the item of $242,000 for pay and rations of officers and men. But the pay and rations of officers must be excepted, for this witness says :

"It is a question of the saving of about $100,000. You can keep it [the hydrographic work] where it is, put all the money intended for hydrographic use, *except the salaries of officers and their rations*, in the Coast Survey appropriation, to be spent under the Superintendent of the Coast Survey, and save $100,000."

The italics are mine. Following Mr. Colonna in this, and deducting the amounts for pay and rations of officers, which he states elsewhere to be $106,000, there remains a sum of $136,000, of which $100,000 is to be saved.

Deducting the $100,000 to be saved, we have left $36,000 with which to pay and feed during one year the crews of all the Coast Survey vessels engaged in hydrographic work, as well as all shipkeepers ; the absurdity of which is evident.

In my own testimony before the Commission I have referred to this question of discharging crews in all cases as soon as work stops, and I shall not do so here further than to remark that the matter is a minor one of administration, requiring knowledge of the special circumstances in each case, and coming directly within the scope of the duties of the Hydrographic Inspector. If Mr. Colonna's crude suggestion were followed in all cases, the result would probably appear to show a saving on the face of the accounts. The result of a careful computation, which covers a year during which circumstances cause the showing against the present system to be peculiarly unfavorable, and in which all doubtful elements are so entered as to make the result still more unfavorable, shows that the saving to be effected amounts to less than $23,000, and this at the expense of efficiency.

Mr. Colonna submits a comparative statement of the expenses of the schooner Yukon in the hands of a civil party, and those of the schooner Earnest in the hands of a naval party, and the showing, as he puts it, is unfavorable for the latter. As it is my purpose to be brief, I shall not go into an analysis of the statement, further than to say that instead of being a fair comparison and example it is really most unfair, and the case an exceptional one. The two parties were equipped for totally different kinds of work. One was to do topography, the vessel serving simply as headquarters for the small force needed. The other was to do hydrography, using steam launch and pulling boats, and required a large force. *After equipping at considerable expense,*

the party on board the Earnest was ordered, by direction of the Superintendent of the Coast Survey, to cease operations, although a slight additional allowance of money would have enabled work to be carried on with gratifying results. The crew was reduced; all were not discharged. I have already considered the question of discharging crews on the Pacific coast, when I had the honor to appear before the Commission.

The consideration of the expense of this work will be of interest. Director Powell testifies (p. 638) that the cost of the topography executed by the Coast Survey has been $100 per square mile, and that the map they propose to make will consist of 400,000 sheets, to cost $350,000,000. This cost of $100 per square mile is admitted by the witnesses, and it is not denied that it costs more.

The most conclusive *résumé* of this question, which is based on information received directly from the Coast Survey Office, is found on pp. 532–533 of the exhaustive, comprehensive and exceedingly interesting report of Captain G. M. Wheeler, U. S. Engineers, already referred to.

"The amounts appropriated for this work from 1806 to June 30, 1886, aggregate $20,072,136.56. The current annual appropriation is $523,398.82, with $100,000 for purchase of vessels."

"There has been directly expended by the Coast Survey from its own appropriations to June 30, 1884, the sum of $19,349,112.03 (see Sen. Ex. Doc. No. 35, 31st Cong., 2d Sess., and testimony before Joint Congressional Commission, p. 61). The above is independent of the expense borne by Army and Navy appropriations. The former ceased during the War of the Rebellion."

"The Secretary of the Navy, in his annual report for 1882, gives the following as actual expenditures from Navy appropriations for the Coast Survey: 1879, $260,870.63; 1880, $229,969.32; 1881, $220,-931.64. The expense borne by the War Department is not known."

"Commander Sigsbee, U. S. Navy, estimates (see p. 252 Annual Report of Secretary of the Navy, 1882) $4,000,000 as the lowest total estimated amount of expenditure for all years (presumably to June 30, 1882), thus aggregating an expenditure (actual and estimated) to June 30, 1884, of $23,349,122.03, with the cost to the Navy of two additional years. Every expense for the fiscal year ending June 30, 1885, is given (see p. 553 of testimony) at $449,324. This swells the actual direct expenditure to June 30, 1885, to the sum of $19,798,-436.03. Add $201,563.07 (an amount presumably underestimated), an assumed expenditure for the half year ending January 1, 1886

(making round numbers), and there results the sum of $20,000,000. To the $4,000,000 (estimated cost to Navy to June 30, 1882) the sum of $593,143, being for 2½ years to January 1, 1886, at an average of $237,257.20 (see Annual Report of Secretary of the Navy, p. 252), and there results as a total direct Navy expenditure (estimated) $4,592,143. The aggregate of expenditure to January 1, 1886, thus reaches the figure of $24,593,143. The relative percentage of hydrographic to trigonometric work is estimated as $\frac{3}{10}$ and $\frac{2}{10}$ of the whole, and that for topography at $\frac{4}{10}$, with the balance, or $\frac{1}{10}$, for work of a general character. (See p. 148 of testimony before Joint Congressional Commission.) Grouping the official data, all from the office of the Coast Survey, there results the following table:

Class of work.	Area in sq. miles.	Total estimated cost of same.	Cost per sq. mile.	Remarks.
Triangulation...............	199,864	$4,918,628 60	$ 25 80	Both coastwise and interior.
Topography.................	31,919	9,837,257 20	308 00	Add cost of triangulation, base and astronomic work for cost of 1 sq. mile, topography mapped.
Hydrography (inshore).	26,093	7,377,943 90	93 00	Add cost of triangulation, base and astronomic work for cost of 1 sq. mile, hydrography mapped.
Hydrography (offshore)	53,030			

"The cost to the United States, as above shown, for one square mile of topography on the resultant map would be $333, increased by the expense of the initial astronomic work, measured bases, and preliminary work, which are presumably a part of the one-tenth for general work. The cost of the inshore hydrography (being more detailed) is probably at least three times as much as that of the offshore; hence, the sum of $93 per square mile represents only a part of the true cost of one square mile of complete, detailed hydrography."

"The above is the most complete estimate yet made of the actual cost of finished work by this office. General Comstock made an estimate, based on Coast Survey reports from 1858 to 1872, of the average cost for 14 years as follows: "Triangulation per square mile, $120; topography per square mile, 283; hydrography per square mile, 80. (See Sen. Ex. Doc. No. 21, Part II., 45th Cong., 3d Sess., 30th January, 1879.) The amount for topography *per se* is not far

different from that obtained by measuring the final total results and taking the corresponding total cost. The item for triangulation, however, varies greatly. At that date not so large a proportionate part of offshore hydrography had been done."

One more consideration demands attention. The acquisition of modern war ships may bring in its train such changes in organization as will effect results long desired. This is the belief of some, at least, and the hope of many. It seems to me, however, a doubtful consummation, unless some imperative occasion should arise to call a widespread attention to the Navy, and give it the support of a strong and favorable public sentiment. The demand for the most efficient service would then force the organization to conform to the necessities of the situation, and complaints of defective administration would not be so frequent.

Without this special occasion we cannot count on the interest of those of our people whose homes are not within easy striking distance of the seacoast, and the most we can expect to secure is the attention and assistance of the commercial classes of the seaboard and their most worthy associates, the mercantile marine. No effort should be spared to bring the Navy into favorable relations with these classes, and its services, freely offered and wisely distributed, will react in the strongest measures of public sympathy and support. This has been fully exemplified by the successful career of the Hydrographic Office during the last two years and a half. Excluded from the direction of the special service which would bring it into the closest relations with the individuals of the maritime community, it has yet found much to do for their benefit and instruction, and stands as high to-day in the popular regard as any bureau of the Government.

That service, however, which the Navy performs most acceptably, and which, under proper management, would bring the largest measure of credit to the Navy Department, is swallowed up in the assets of the Treasury, and the identity of the body which surveys the coast is lost in the operations of the Coast and Geodetic Survey. The influence which naturally accrues to the direction of this great and valuable work is lost to the department which furnishes the workmen and a large share of the money for its prosecution. Can the Navy afford to bear this loss any longer?

U. S. Hydrographic Office,
April, 1886.

PROFESSIONAL NOTES.

A STRANGE FAILURE OF STEEL BOILERS.

[From the London *Engineer.*]

The peculiarity of the boilers under consideration consisted in the fact that (1) the material used passed all the tests required by the Board of Trade and Lloyd's; (2) the material stood without the slightest defect the ordinary work of the boiler shop, including welding, etc.; (3) each set of boilers worked most satisfactorily at sea for a period of two and a half years, after which they then exhibited signs that a complete change had taken place in the steel.

The design of the boilers was such as to give no reasons whatever for the strange behavior of the material, being the ordinary double-ended, cylindrical type with three plain, welded furnaces opening into a separate chamber for the set of three at each end, and having on top of each boiler an ordinary cylindrical drum.

From the commencement of the working of these boilers the usual treatment was adopted, zinc being used in blocks of the Admiralty pattern, and special attention was giving to careful scaling. The first signs of a change commenced with an extensive crack in one of the combustion chamber plates on steamer No. 1. This crack, 2 ft. 6 in. long and opening from $\frac{1}{8}$ to $\frac{1}{16}$ in., occurred spontaneously in the month of August, three weeks after the boilers had been blown down, and at the time no work was being done except the usual scaling.

The next occurrence was of a similar nature, but happened to steamer No. 2, when the boilers had reached the same period of working as those on steamer No. 1. This extensive crack occurred in a corresponding plate in the same combustion chamber to the first one, thirteen days after steam had been let down. The report was so loud as to almost deafen a boilermaker at work about the bridges. Owing to this crack being similar to the first one, it was decided to test the other plates of the chamber by hammer blows, with the result that three of the other similar plates were cracked, either vertically or horizontally. Some of the cracks commenced at first by showing a peculiar black shade, about $\frac{1}{2}$ in. broad, in the direction the crack was likely to occur, and after another blow a faint score, like a hair, became visible, which could be seen gradually opening and extending; others cracked simultaneously with the blow, but none with the loud report of the originals. About this time, also, small cracks were found between rivet holes in the furnace fronts and backs, saddle plates, etc.; so that it was evident something unusual was taking place, as previous to this no sign of brittleness had ever been found.

The next crack occurred a few months after on steamer No. 2, when under steam on a long passage home. It was first noticed at sea by the water flowing from the ash-pit, and as no sudden leak took place, it was surmised that the crack opened gradually and salted up as it extended.

At about this time the most serious defect occurred in steamer No. 1, when lying in a colonial port, a few days after steam had been let off. An extensive circumferential crack occurred in one of the wing furnaces. This crack took place with a loud report, commenced about 4 inches under grate bars, and extended upward about 22 inches.

Previous to the receipt of this news, a series of extensive tests had been made in the presence of a Board of Trade official on strips taken from the

cracked plates cut out of both vessels. From these, and also from the chemical tests, no definite signs of an entire change in the material were discovered which would account for the cracks or justify the costly step of removing the boilers, although brittle portions had been found here and there. The analyst's report of the steel was "that, chemically speaking, it is not at all objectionable, being a material of good average quality."

Another instance of the peculiar nature of the steel was found on the last voyage made with the boilers, and consisted of two bulges on the furnace crown close to the back end; the plates in the neighborhood of these bulges showed no signs of brittleness even when put back, whereas numerous cracks were found between the rivet holes at each end, both prior to and after the putting back.

Owing to these occurrences it was decided to have new steel boilers, and when the work of breaking up the old boilers commenced, the results were startling, and of such interest as to bear an extended description. The first start was made by knocking off the rivet heads on the connecting pipes between boilers and drums; but after a few blows it was discovered that the pipes were cracking in all directions, and to such an extent, eventually, that not one of the nine connecting pipes came off whole; then, after the drum had been removed from one boiler, a portion of one of the pipe flanges was being wedged from the boiler, when the shell plate suddenly cracked for about ten inches. When the furnaces and front plates were started upon, a general smash was experienced, the front plates cracking and starring and the flanges breaking off, the furnaces at the same time acting in the same manner, cracking through the rivet holes to such an extent as to allow the ends to come off whole in hoops.

During the construction of the boiler no special means were adopted. The steel, which was made by the Bessemer process, at the works of a prominent steel company, worked in a most satisfactory way, welding and flanging without the least trouble; the holes in shell and other circular portions were drilled; the furnaces, after being welded, were carefully annealed to the special instructions of the Board of Trade, the work throughout being regularly inspected by their surveyors and those of Lloyd's Registry, the material having also been periodically tested at the manufacturers' by both these boards.

It will now be interesting to endeavor to obtain, if possible, some satisfactory reasons for the failure of these boilers; otherwise, the unpleasant fact must be acknowledged that it is yet possible for material to be put into boilers which after a time will become treacherous, notwithstanding the extensive tests and rigid inspections now made.

J. K. B.

NOTES ON LIQUID FUEL.

[From the London *Times*.]

The expenditure of ingenuity, time and money which has been going steadily on for many years past in the endeavor to utilize hydrocarbons as fuel under boilers for raising steam, testifies to the importance of the subject, while the persistency with which it continues to be pursued bears witness to its fascination, and to the valuable character of the results which are expected to follow practical success. That success would mean an enormous saving in our solid-fuel coal, while our steamships would be relieved of some 50 per cent. of their fuel weight, which could be either assigned to cargo, or, on long voyages, a double supply of liquid fuel could be carried. So long ago as 1830 Mr. H. Pinkus claimed to have used hydrocarbons in conjunction with streams of vapor for steam-raising purposes, and from that time down to the present, engineers and inventors have not, for any length of time, ceased to labor in the same direction. Richardson's petroleum furnace, as well as that of Bridges

Adams, was for many years under the notice of the officials in Woolwich Dockyards, and in 1868 the Government permitted Wise, Field, and Aydon's systems of using petroleum by the aid of an induced current to be applied to a marine boiler on board a steam yacht. The same system had also been previously applied to a Cornish boiler at some large works in London. The Admiralty also tried at Sheerness a somewhat similar plan, invented by Mr. S. E. Crow, but, as in the Woolwich trials, without any practical result. In the same year, which appears to have been marked by a sudden outbreak of inventive activity in connection with the subject of liquid fuel, Dorsett's petroleum furnace was fitted under the boilers of the steamship Retriever, of 90-horse power and 500 tons burden, and some very successful runs were made with her. But, as far as the use of the system in England went, nothing further appears to have resulted, the reason being, we believe, that directly a demand was created for the class of liquid fuel used, and which at that time was a drug on the market, the prices went up to a prohibitive extent.

In France corresponding attention was paid to the same subject and in the sàme year, one system tried there being that of M. Verstraët, a chemist. It was applied to a locomotive on the Eastern of France Railway, and upon the occasion of the Emperor visiting the camp at Châlons the train was drawn by the engine thus fitted. His Majesty rode on the foot-plate of the engine, in company with MM. Sauvage, Dieudonné, and Sainte-Claire-Deville. In the same year, His Majesty also made a run in the Puebla, a steamer in which mineral oil was employed to raise the steam for the engines. In America, liquid fuel has been used both on locomotives and in steamers, and at one time, we believe, to a considerable extent, but, notwithstanding the advantages offered in the way of cheap and plenteous liquid fuel, it would seem to have had but a very limited application in practice for steam-raising purposes. In Russia a very different condition of matters exists, inasmuch as for some years past petroleum refuse has been used for fuel in the locomotives of the Grazi Tsaritsin Railway, in the southeast of Russia, the first trials on that line having been made in 1874. Besides this, numbers of steamers are now running on the Caspian Sea which are using liquid fuel. Moreover, in consequence of the comparative scarcity and dearness of petroleum in this country, a fleet of large tank-steamers is being built by the Russian Black Sea Navigation Company to bring the Russian oil to Europe in bulk.

In view of the undoubted importance of the liquid-fuel question, it will be interesting now to notice its latest phase, as brought under our notice on Wednesday in the steamship Himalaya. This is a trading vessel of 100-horse power, nominal, and 800 tons burden. She is 210 feet long, and 28 feet beam, and is fitted with compound engines, driving a screw propeller. The boilers have three furnaces, each of which has a fire-brick lining with apertures on the principle of the Siemens regenerative system. At the end of each furnace is a fire-brick baffle having an opening through which the heat passes to the tubes from the furnace, or, as it may be more correctly called, the combustion chamber. In this chamber is a coil of iron pipes, one end of which is connected with the steam space of the boiler and the other opens at the door of the chamber. This coil is for the purpose of superheating steam taken from the boiler, and by which an induced current is set up which carries the petroleum forward into the combustion chamber. In order to enable it to do this, the petroleum nozzle is placed within the steam pipe at the opening where it delivers its jet, so that an annular space is formed, through which the steam rushes, and, combining with the small but regular flow of oil, produces a large body of flame within the chamber. The oil is stored in tanks on the main deck, whence it flows by gravity to the delivery nozzles at the furnaces. The whole apparatus is very simple and very easily adjustable ; one important feature is that in the event of the oil not being obtainable at any port where fuel is required it can be removed, and the fire bars for burning coal replaced in a very short time. Another important feature of the system which we should mention (the invention of Mr. Percy F. Tarbutt) is the method of

starting the furnace, which is effected by a very simple arrangement, whereby sufficient steam is quickly raised to start and maintain combustion until the steam pressure in the boilers is sufficient for that purpose.

The Himalaya was purchased by the Marahū Petroleum and Oil Produce Company, of Suffolk House, Cannon street, London, and by them has been fitted with the apparatus we have described, in order to practically and commercially test the system. She will, however, be renamed the Marahū, after her owners, the Marahū Company. The coal-carrying capacity of this vessel is said to be 240 tons, and her consumption of that fuel is put at nine tons per day. She will now carry only 90 tons of oil, her consumption of liquid fuel being put at 3½ tons per day, thus giving, as we have already observed, a great increase of cargo capacity. A large party of engineers and other gentlemen interested in the present question visited the Himalaya on Wednesday and inspected the furnaces and oil equipment of that vessel. Although only that morning completed, the apparatus worked very well, combustion being nearly perfect, as evidenced by the very small amount of smoke that issued from her funnel. A fairly steady steam pressure of 55 pounds per square inch was maintained, the steam, of course, being blown off as made. The demonstration, in fact, was perfectly successful. The ship will start to-morrow on a trial trip to Leith and back. She will be accompanied on the trip by a Board of Trade surveyor, as well as by one of Lloyd's surveyors, both of which departments are evincing great interest in the trial. After that she will proceed to Glasgow to take in a cargo, which she will carry to Brazil. It is then intended to employ her for trading purposes along the coast of Brazil, her supply of liquid fuel being obtained there from the works of the company to whom she belongs.

Such is the latest phase of the liquid-fuel question, which appears to be nearing solution as regards steamships. It appears to be clearly demonstrated that petroleum can be used as fuel. The only disturbing element as regards commercial success here is the uncertainty and the cost of the supply. This difficulty surmounted—and it would seem that Russian enterprise is about to make an attempt to surmount it—and prejudice and conflicting interests overcome, there would appear to be a hopeful future for liquid fuel in this country. In fact, Wednesday's demonstration looks like the beginning of the end.

It is feared that the sanguine expectations expressed in the preceding article will not be realized in the near future, as the impracticability of the general use of liquid fuel by any system tested up to the present time, when considered from a commercial standpoint, is distinctly shown by the following tables, taken from a paper read before the Engineers' Club of Philadelphia, by Mr. James Beatty, Jr., member, and printed in the *American Engineer :*

"The fuels to be considered are anthracite and bituminous coals, crude petroleum, and coal, generator and water gases. The average compositions of these fuels (considering only the heating agents), as deduced from the analyses of eminent chemists, are :

	Percentage by Weight.					
	C.	H.	O.	CO.	CH_4.	C_2H_4.
Anthracite	87.7	3.3	3.2			
Bituminous	80.8	5.0	8.2			
Petroleum..........	84.8	13.1	1.5			
Coal gas.............		6.5		14.3	52.4	14.8
Generator gas......		1.98		35.5	1.46	
Water gas..........		6.3	.6	87.8	1.2	

"We will employ the formula of Dulong,

$$h = 14{,}500\,C + 62{,}000\left(H - \frac{O}{8}\right),$$

to compute the theoretical heating powers of these fuels. In the case of methane, CH_4, the formula is not true, but the error is not great enough to seriously affect the result. This gives for the combustion of one pound of

Anthracite	14,500 Br. heat units.	
Bituminous	14,200	"
Petroleum	20,300	"
Coal gas	20,200	"
Generator gas	3,100	"
Water gas	8,500	"

"Reducing the above to terms of pounds of water evaporated from 212° F., we have :

	Pounds of Water evaporated from 212° F.
Anthracite	15.023
Bituminous	14.69
Petroleum	21.00
Coal gas	20.87
Generator gas	3.21
Water gas	8.7

"The results of experiments show the efficiency of fluid-burning furnaces to be about 90 per cent., while with coal 60 per cent. may be taken as a good figure. The great difference in the efficiencies is due to the fact that fluid fuels require for combustion very little air above the theoretical quantity, while with the solid fuels fully twice the theoretical quantity must be admitted to dilute the products of combustion.

"Correcting our previous results from these efficiencies, we have :

"Pounds of water actually evaporated from 212° F. :

	Per pound of Fuel.
Anthracite	9.0
Bituminous	8.8
Petroleum	18.9
Coal gas	18.8
Generator gas	2.9
Water gas	7.8

"These figures agree closely with the results of experiments.

"We will now consider the subject of cost.

"The following cities have been selected, as manufacturing centres, termini of railroads, or fueling ports of steamers.

"In the case of petroleum, as it is rarely shipped in the crude state, an approximation is made by adding to the cost to the nearest shipping port the freight charged on refined petroleum, and ten per cent. to cover duties and other charges.

"Owing to the difficulty in obtaining prices in some of the cities, there may be some errors.

Costs, March, 1884.

	Anthracite, per ton of 2240 lbs.	Bituminous, per ton of 2240 lbs.	Coal gas, per 1000 cu. feet.	Generator gas, per 1000 cubic feet.	Crude petroleum, per bbl. of 42 gallons.	Water gas, per 1000 cubic feet.
New York	$4 00	$4 25	$1 75	$0 45	$1 80	$0 50
Chicago	5 00	3 50	1 25	0 45	2 00	0 50
New Orleans	6 00	3 50	3 00	0 45	2 50	0 50
San Francisco	12 00	7 50	3 00	0 55	2 00	0 60
London	5 00	3 00	0 75	0 43	2 70	0 45
Port Natal	12 50	11 00	...	...	4 00	...
Sydney	12 00	7 00	...	...	4 50	..
Valparaiso	11 50	7 50	...	...	3 00	...

"In calculating the following table the specific gravity of coal gas is taken at .4; generator gas at .44; water gas at .48; petroleum at .8.

Pounds of Fuel for $1. March, 1884.

	Anthracite.	Bituminous.	Petroleum.	Coal Gas.	Water Gas.	Generator Gas.
New York	560	527	156	18	74	76
Chicago	448	640	142	24	74	76
New Orleans	374	640	114	10	74	76
San Francisco	187	299	142	10	62	62
London	448	747	104	40	82	79
Port Natal	179	204	71	...	...	...
Sydney	187	320	63	...	...	...
Valparaiso	195	•299	94	...	...	...

"These figures, multiplied by the actual evaporative powers as calculated, give:

Pounds of Water Evaporated from 212° F. for $1.

	Anthracite.	Bituminous.	Petroleum.	Coal Gas.	Generator Gas.	Water Gas.
New York	5040	4643	2948	338	220	577
Chicago	4032	5638	2684	451	220	577
New Orleans	3366	5638	2155	188	220	577
San Francisco	1683	2634	2684	188	179	484
London	4032	6581	1966	751	228	640
Port Natal	1611	1797	1342	...	...	...
Sydney	1683	2819	1191	...	...	...
Valparaiso	1755	2634	1776	...	...	...

Relative Costs.

New York	$1 00	$1 08	$1 71	$14 92	$22 90	$8 70
Chicago	1 00	0 71	1 50	8 72	18 30	7 00
New Orleans	1 00	0 59	1 56	17 90	15 30	5 80
San Francisco	1 00	0 64	0 63	8 75	9 40	3 50
London	1 00	0 61	2 05	7 16	17 70	6 30
Port Natal	1 00	0 90	1 21	...	...	...
Sydney	1 00	0 34	1 39	...	...	...
Valparaiso	1 00	0 44	1 03	...	...	...

In the years 1866-7 the Bureau of Steam Engineering of the Navy Department made an elaborate series of experiments to ascertain the value of crude petroleum as a fuel for generating steam in marine boilers. These trials were considered to have solved the engineering problem concerned in the use of

petroleum, as the apparatus invented by First Assistant Engineer Clark Fisher, of the United States Navy, was found to be a complete success. It was similar in principle to the apparatus described above as fitted to the Himalaya, but was more complete in having an additional annular space about the steam jet for the supply of air. Thus the steam not only atomized the petroleum, but diffused throughout it the air necessary for combustion.

Chief Engineer B. F. Isherwood, then Chief of the Bureau of Steam Engineering, discussed the results of the trials in his annual report, dated October 25, 1867, as follows:

"With Fisher's apparatus it is found that, other things equal, the heat generated by the combustion of one pound of crude petroleum vaporizes fifty-two per cent. more water than that generated by the combustion of one pound of the combustible portion of anthracite; by combustible portion is meant the part which remains after deducting the earthy matter. To cause the complete combustion of the petroleum, about one-twelfth of the steam generated by it has to be used in the furnace, leaving the effective vaporizations produced by the two fuels to compare as 1.00 for the anthracite combustible and 1.40 for the petroleum. And, as the earthy matter of good, merchantable anthracite is about one-sixth of its weight, the effective vaporization produced by equal weights of anthracite and petroleum will compare as 1.00 for the former to 1.68 for the latter. These figures are, of course, for the same weight of anthracite combustible and of petroleum consumed in the same time in the same boiler.

"The advantages of the substitution of petroleum for anthracite would then be a reduction of forty and a half per cent. of the weight of fuel now carried in the vessel; and as the cubic foot of petroleum weighs at ordinary temperatures fifty pounds, while the cubic foot of anthracite as stowed in bunkers weighs fifty-three and one-third pounds, there would be a reduction of bulk of thirty-six and a half per cent.

"As, however, the iron tanks required to hold the petroleum would weigh considerably more than the bunkers holding the anthracite, and as some space must necessarily be lost in storing them, it may be assumed that the substitution of petroleum for anthracite would reduce both the weight and space required for the latter about one-third. But if safety required the petroleum tanks to be immersed in water, as at present seems probable, then no saving of weight could be effected, but only a saving of space occupied. The weight of the boiler, including its water, and the space occupied by it and the fire-room, could be reduced twenty-eight and a half per cent. The first cost and after repairs of the boiler would also be reduced to the same extent. The number of firemen required with petroleum would not exceed one-fourth the number required with anthracite, leaving their pay and subsistence to be saved, as well as their weight and that of their effects and subsistence, and the space occupied by all three on board. The petroleum fire starts into full activity instantaneously, and is as instantaneously extinguished, while the coal fire requires about an hour to attain steady action, and as long to burn out. These are very important advantages; but against them are to be placed:

1st. The danger resulting from the very volatile gases which petroleum emits at ordinary atmospheric temperatures, and which, when mixed with air, are highly explosive. In the hold of steamers the temperature around the engine and boiler-rooms averages as high as one hundred degrees Fahrenheit, and greatly aggravates this danger. Indeed, when it is considered that a medium-sized navy steamer would have to carry about two hundred and fifty tons of petroleum, which, however well protected in tanks, is liable by a single shot to be poured in large quantities into the boiler-room, where its gases, mixed with the air and ignited by the fires of the furnaces, would explode with terrific effect, liberating other quantities and destroying almost instantaneously both vessel and crew, this objection seems so serious that the most overwhelming advantages are required to justify the risk of its use. As merchant steamers do not engage in battle, this risk would be less for them, but it would cause a high

rate of insurance and loss of passenger transportation, even if officers and crew could be found for excessive pay to brave the danger.

"2d. Owing to the rapid conversion into gases of a portion of it at ordinary atmospheric temperatures, the loss of petroleum by volatilization is very great, and this loss proportionally increases its cost, while it decreases its advantages as regards bulk, weight, and evaporative efficiency.

"3d. And, due to the same fact of its easy gasification, it fills the air with a noisome stench, which, in the confined hold and badly ventilated compartments of vessels, would be intolerable.

"4th. The price of crude petroleum is, by weight, about eight times that of coal, and a large demand would increase the disparity.

"From these considerations, it appears that the use of petroleum as a fuel for steamers is hopeless; convenience is against it, comfort is against it, health is against it, economy is against it, and safety is against it. Opposed to these, the advantages of the probably not very important reduction in bulk and weight, with their attending economies, cannot prevail."

The ratio of the effective evaporative efficiencies of anthracite and petroleum as given by Isherwood, 1 to 1.68, is undoubtedly more reliable than Mr. Beatty's estimate, 1 to 2.1, which does not give evidence of including the loss from the use of steam in burning the petroleum. Thus, if Isherwood's ratio be adopted, the relative cost of evaporating water by coal and petroleum would show an increase of twenty per cent. over the figures given by Mr. Beatty.

It will be noticed that San Francisco is the only place shown where it is more economical to use petroleum than coal, and, curiously enough, it appears to be the only place in America where it is used in a steamer. There the large ferry-boat, owned by the Central Pacific Railroad, for transporting the overland trains from Port Costa to Benicia employs petroleum furnaces. The circumstances are peculiarly favorable to economy, as the vessel remains at the dock for some time between the short runs, occupying about forty minutes. On reaching the dock the supply of fuel is stopped completely, and the heat stored in the bricks forming the furnaces is sufficient to keep up steam.

It may be argued that the matter of greater cost of petroleum does not render its use commercially impracticable, as the saving in cargo space from the reduction of bulk of the fuel and the reduction in weight and space for boilers would increase the earning capacity of a steamer to such an extent as to overcome the loss upon the fuel. In some special cases this might occur, but ordinarily there would appear to be an invariable loss, without considering the rise in the price of petroleum if generally used as steamship fuel, or the increase in rates of insurance.

For war purposes, considered apart from the question of cost, we may say that if we agree to provide for the use of petroleum when full power is required, or as emergency fuel, then the weight of boilers may be reduced by about one-third for the same space. The question is whether this gain in useful displacement can be utilized to such advantage as to counterbalance the enormous additional risks involved by the use of petroleum.

F. T. B.

REPORT BY A BOARD OF U. S. NAVAL ENGINEERS ON THE RELATIVE STEERING EFFICIENCIES OF THE RUDDER ALONE, AND THE KUNSTADTER SYSTEM OF RUDDER AND SWIVELLING SCREW.

In this report will be found the dimensions and descriptions of the hull, screw, boilers and motive engines of the vessel, and of the two systems of steering in question; a description of the manner in which the experiments

were made, and of the means by which they were made; large tables in which every experimental quantity, either of observation or calculation, will be found systematically arranged, and in connection with which are explanations of the quantities in these tables, showing how they were obtained; an investigation into the principles which govern the action of each of the two systems of steering; a statement of the general laws discovered by reason and confirmed by the experimental measures in the two cases; also, a statement of the practical results as ascertained for both systems; and, finally, a comparison of the experimental results, and of the value of the two steering systems.

The experiments were made for every five degrees of rudder angle between 10 and 45°, and made for turning the vessel first to starboard and then to port, the mean being taken as the true result, each turning being repeated from five to seven times in order to obtain an accurate mean. These trials were repeated for three rates of speed. The power exerted by the engine was correctly ascertained in each case; during the experiments, over 13,000 indicator diagrams were taken and computed.

Among many other determinations, the experiments show that the resistance of a given plane moving in water, and inclined at different angles of obliquity to the direction of its motion, experiences a resistance in the direct ratio of the sine of the angle of obliquity; that the diameters of the turning circles of a vessel at constant speed upon the circumferences of those circles, and steered by the rudder alone, are in the ratio of the product of the natural sine and cosine of the angles made by the rudder with the keel; that the diameter of the turning circle with same rudder angle is greatly influenced by the speed of the vessel on the circumference of that circle, becoming larger as the speed increases; and that the angle of greatest steering effect for the rudder alone is 45°.

For the Kunstadter system, the experiments have shown that the vessel steered by it has the diameters of its turning circles in the direct ratio of the natural cotangents of the angles made by the rudder with the keel from aft, provided the vessel has a constant speed on the circumferences of those circles; and that their diameters are affected by difference in these speeds in the same manner and to the same degree as in the case of the rudder alone, becoming larger as the speed increases.

The report also shows for the first time the causes which determine the "drift angle" or turning angle of the vessel, and the method of calculating it with exactness when the diameter of the turning circle is known. The "drift angle" is the angle made by the central longitudinal plane of the vessel with a tangent to the circumference of the turning circle, at the point where the centre of gravity of the vessel coincides with or is over that circumference. This angle is constant for the same vessel and the same diameter of turning circle during the entire time that the vessel is making a revolution around the circle. If the diameter of the circle be increased, the "drift angle" is lessened, and *vice-versa.*

The report also shows that the vessel does not pass around upon the circumference of the turning circle as though it lay fixed across that circumference at the "drift angle" and was carried around upon the circumference broadside to, as it were, by a force following the circumferential direction. The vessel follows the circumference as the resultant of two component forces acting independently of each other, so that the movement obtained from its screw is always in the direction of its central longitudinal plane, while it simultaneously undergoes a purely rotary movement on its centre of gravity from the force derived from the reaction of the water upon the rudder.

The small screw, steering screw, or Kunstadter screw, as it is severally named, is of cast iron, the blades and hub forming a single casting. The shaft of the small screw is supported in a continuous bearing extending clear across the rudder. The shaft is cased with brass, and runs on lignum-vitæ bushings in the usual manner. The thrust of the screw, in both going ahead and backing,

is taken through a brass collar and lignum-vitæ bearing by the rudder, to the pintals of which it is transferred, and by them to the rudder-post and hull. The brass collar and lignum-vitæ bearing are at each end of the rudder, those for the going-ahead thrust being at the after end. By this arrangement the small screw is supported overhung just abaft the rudder, and when the main screw and the Kunstadter screw are at right angles to the central longitudinal plane of the vessel, the axes of their shafts are in the same straight line.

The small screw makes revolution for revolution with the large one, the two being connected by a universal joint lying directly between them, and enabling the axis of the small screw to be placed, by a force acting on the rudder, at any angle less than about 55° with the axis of the large screw. The small screw thus becomes a steering screw, in addition to the rudder.

The universal joint connecting the main and small screws is of the utmost mechanical simplicity, convenience and efficiency.

The experiments made with the two systems of steering consisted—1, in ascertaining the performance of the Nina over a straight base with and without the small screw; 2, backing trials in a straight line at the maximum, with and without the small screw; and 3, turning trials.

The primary object of making the runs over the bases was to ascertain the distance in feet that the vessel passed through the water in a straight line per revolution of the speed register, an instrument that was employed for determining the lengths of the circumferences of the circles described by the centre of gravity of the vessel with different angles of helm. When the small or Kunstadter screw was not used, there were utilized in the propulsion of the vessel 75.882 per cent. of the net horse-power developed by the engine, and when the small screw was used, there were utilized in the propulsion of the vessel 74.386 per cent. of the net horse-power developed. This difference is an economical loss of about 1½ per cent. of the net power, and was accounted as being wholly due to the malproportion of the two screws used.

All attempts to steer the Nina when backing with the main screw alone proved completely abortive. The position of the rudder seemed to produce absolutely no effect, and the result was the same whether the rudder was in the line of the keel or made any angle with it up to 45°, and on either side. With the small or Kunstadter screw in use, it was possible, by careful watching and quick handling of the helm, to back the vessel in a straight line.

The object of the turning trials was competitive—to ascertain, in the two cases of steering, the diameters of the circles respectively made by the centre of gravity of the hull with the rudder and with the axis of the Kunstadter screw at the angles of 10, 15, 20, 25, 30, 35, 40 and 45°, the vessel turning both to starboard and to port at three rates of speed. It was found that the relative steering efficiencies of the two systems varied largely with different angles of the rudder. At the rudder angle of 45°, the steering efficiency of the rudder alone was nearly 66 per cent. less than that of the Kunstadter system, the diameters of the turning circles in the two cases being nearly in the rates of 166 for the rudder alone and 100 for the Kunstadter system. As the rudder angle decreases, the Kunstadter system gradually loses its superiority, until at the angle of about 25° the steering efficiencies of the two systems are about equal. Below the rudder angle of 25° the rudder alone gradually gains in superiority, until at 10° it exceeds the Kunstadter system in steering efficiency nearly 15 per cent., the diameters of the turning circles comparing as 85 for the rudder alone and 100 for the Kunstadter system.

It is stated that, had the Nina been fitted with a rudder and fixed propelling screw of the proportions to the hull found in the best engineering practice, instead of the exaggerated proportions they actually had, the superiority of the Kunstadter system at 45°, instead of being 66 per cent. greater than the rudder alone at the same angle, would have been about 100 per cent. greater, as the turning circles with that angle of rudder would have been about one-half the diameter with the Kunstadter system that it would have been with the rudder alone.

The best arrangement of the two screws, as the result of the experiments with the Nina, appears to be that they should be duplicates, and that when joined they should form one screw whose dimensions should be those which good engineering practice would give to a single screw.

The Kunstadter system possesses the advantage that it requires no special adaptation of the engine, and can be applied to a vessel already fitted with the ordinary screw at but little more cost than if made for her in her original construction.

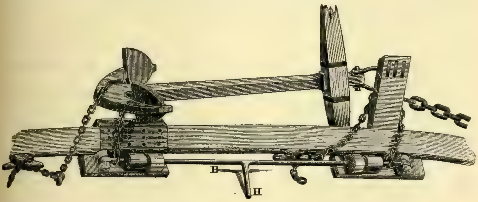
The immense advantages arising, especially for fighting vessels, from superior manœuvring power are so numerous, and the improvement in this respect offered by the Kunstadter system is so great, and involves so little cost or complexity, that the board in its report recommends the application of the system to all screw steamers of the Navy.

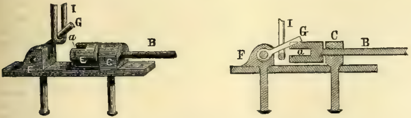
J. K. B.

NOTE.

The U. S. Patent No. 275,529, granted to T. H. Sellers, of Vallejo, Cal., is for a very simple and effective boat-detaching apparatus that has been successfully applied to several of our vessels of war in the Pacific. The device is so simple and strong in all its parts that its application was suggested for use in letting go the bower anchors of a vessel of war. The accompanying drawings show the nature of the apparatus and its application to the bower anchors of the U. S. S. Mohican. Certainty of action in clearing the ring stopper and shank painter at the same instant is absolutely secured.

H. G.





Referring to the drawings for a more complete explanation, Fig. 1 is a perspective view of the forecastle of U. S. S. Mohican; Fig. 2 is an enlarged view of one end of the device; Fig. 3 is a section of the same. *B* is a shaft

that extends fore and aft parallel with the ship's rail, and as close to it as possible. The ends of the shaft may be enlarged, as shown at *E*, and have short slots, *a*, cut in one side, extending to or just beyond the central line or axis of the shaft. Beyond the ends of the shaft are boxes *F*, which, for convenience of fastening and solidity, may be formed upon or secured to the same base with the boxes *C*. Bolts *G* have one end pivoted in the boxes *F*, so that their free ends may turn in a line with the axis of the shaft and lie in slots *a*. The shaft *B* has a lever, *H*, at any suitable point, by which it can be rotated, so that when the ends of the bolts are in the slots, by turning the lever up the slot will face downward, and the bolts cannot be withdrawn until the shaft has been again turned with the slot upward. A link, *I*, is made to fit over each of these bolts, being the standing part of the ring stopper and shank painter.

The operation will be as follows: The bolts *G* pass through the ends of the links *I* and enter the slots *a*. The shaft *B* is turned so that the slots are below horizontal position, which prevents the bolts coming out, and the ring stopper and shank painter are hauled taut and belayed to cleats inside the rail as usual. A half-round chock shod with iron is placed inside the rail in wake of the ring stopper and shank painter to take any chafe. In letting go anchor the lever *H* is first released from a catch which steadies it against the rail and turned down as shown in the drawing until the slots at the end of the shaft are open, when the links are released and the anchor is entirely clear.

TORPEDO WAR AND SUBMARINE EXPLOSIONS.

BY ROBERT FULTON, Fellow of the American Philosophical Society, and of the United States Military and Philosophical Society. New York: Printed by William Elliott, 114 Water Street. 1810.

The Liberty of the Seas will be the Happiness of the Earth.

The above is the title of a rare pamphlet, in the Navy Department Library, written by the great Fulton and addressed to President James Madison and the members of both Houses of Congress, giving a description, with five engravings, of some experiments and details of his method of torpedo defense and attack, which he had unsuccessfully attempted to introduce into the naval establishments of England and France, and which he sought to have adopted as a principal part of our national defense.

The subject being now treated by the Fortifications Board, a comparison of the state of the art of torpedo warfare by the statement of its effectiveness and reasons for employing it will prove interesting and instructive.

Fulton first describes the blowing up of the brig Dorothea, of 200 tons burthen, near Deal, in 1805; done to convince Mr. Pitt and Lord Melville that a vessel could be destroyed by the explosion of a torpedo under her bottom. A torpedo containing 180 pounds of powder was attached to either end of a line 80 feet long stretched between two boats, which then rowed down on the brig until the line struck the cable, when the torpedoes were cast overboard, and, being not quite buoyant, the tide carried them under her bottom.

The destruction of the vessel was complete, and much impressed the officers present, who were previously very dubious as to the value of torpedoes.

In a note Fulton says:

"The morning of my first interview with Earl St. Vincent he was very communicative. I explained to him a torpedo and the Dorothea experiment. He reflected for some time, and then said: 'Pitt was the greatest fool that ever existed, to encourage a mode of war which they who commanded the seas did not want, and which, if successful, would deprive them of it.'"

A similar experiment to that on the Dorothea, made in New York Harbor in 1807, is also related.

Fulton's anchored torpedo consisted of a copper case containing 100 pounds of powder made buoyant of cork. The firing apparatus consisted of a brass box containing a gun-lock, with a barrel two inches long containing a musket-charge of powder; a ship striking the trigger fired the torpedo. The whole was secured to an anchor by a line of such a length that the torpedo would come to within from 10 to 15 feet of the surface at low water.

For torpedo attack, Fulton shows a picture of a "clockwork torpedo as prepared for the attack of a vessel while at anchor or under sail, by harpooning her in the larboard or starboard bow." The torpedo is the same as before described, except that it is fired by clockwork and suspended from a cork float at a depth depending upon the draught of water of the vessel to be attacked. His plan of attack was to run up at night to within 30 to 50 feet of the bow of a vessel anchored in a tideway, or under sail, and fire his harpoon from a blunderbuss mounted in the stern of the rowboat, throw the torpedo overboard, after starting the clockwork, and pull away.

This was twice tried by English officers on French brigs in Boulogne Roads, but without effect, owing to some defect in the method of suspending the torpedoes which made it impossible for the tide to sweep them under the bottom.

The defense of a harbor against the attack of an 80-gun ship, with a full crew of 600 men, by an equal number of men in 50 boats, is described, and great stress laid on the economy of torpedo defense, as it is estimated that the 50 boats, with torpedoes and arms complete, would cost but $25,000, whereas the value of an 80-gun ship was $400,000. This is now a common argument in favor of torpedoes; but the ratio of the cost is probably not so favorable at present, as the boats were then estimated to cost $100 each, and now a 28-foot cutter costs about $800, and a torpedo boat from $30,000 to $50,000. Fulton covered almost every point now considered of value in a modern torpedo boat. He provided four marines to each boat, to keep up a running fire, and estimated that if a vessel were attacked at night, a boat, even if detected at a maximum distance of 300 yards, would not be under fire for more than four minutes. With regard to the danger of such an attack, he says "that the men in the boats, who are not more than three minutes within the line of the enemy's fire, are not so much in danger, nor does it require so much courage, as to lie yard-arm and yardarm, as is now usual in naval engagements, and receive broadsides, together with grape shot and volleys of small-arms, for fifty or sixty minutes. It is not so great a risque, nor does it require so much courage, as to approach a vessel in boats, climb her sides, and take her by boarding. Yet this has been frequently done."

His estimate for the required force was as follows:

"*Estimate for an Establishment in Our Most Important and Vulnerable Ports.*

	Boats.	Anchored Torpedoes.	Clockwork Torpedoes.
Boston..	150	300	300
New York	150	300	300
In the Delaware...	50	200	100
Chesapeake	100	200	200
Charlestown	100	200	200
New Orleans	100	200	200
Total	650	1400	1300

650 boats at three hundred and thirty-six dollars each $218,400
1400 anchoring torpedoes, eighty-four dollars each 117,600
1300 clockwork torpedoes, one hundred and fifty dollars each....... 195,000
Total $531,000

"Having mentioned the ports in which it is most probable the enemy would attempt to make an impression, calculations can be made for a like mode of defending other stations—a minutiæ which I am not prepared to enter into, nor is it necessary, in the present state of this disquisition. I have shown a strong power, in boats and torpedoes, to defend six of our principal ports. Gentlemen will please look to the numbers allotted to each port, and reflect whether an enemy would not be inclined to respect a force so active and tremendous in consequences; a force which, under the cover of the night, could follow them into every position within our waters, and pursue them for some leagues from our shores into the open sea; yet those establishments would not require an expenditure of four hundred thousand dollars; for the cutlasses and firearms to arm the boats, and the powder for the torpedoes, are already in our arsenals and magazines. And what is four hundred thousand dollars in a national point of view? A sum which would little more than build and fit out two ships of 30 guns. After reflecting on these experiments and demonstrations, I hope no one will for a moment hesitate in deciding that the two thousand seven hundred torpedoes and six hundred and fifty boats before estimated will be a better protection for six of our seaports than two ships of thirty or any other number of guns. To man the boats in the different ports, nothing more will be necessary than a marine militia; they can be as numerous as any possible necessity could require; and should be exercised to row, and use the torpedoes until the practice became familiar; after which, practice once a month would be sufficient. Corps thus formed would be no expense to the National Government; torpedoes would require no repairs, and the boats, carefully laid up in houses built for the purpose, would last many years."

In closing the pamphlet, he takes a view of the political economy of the invention, and, with singular shortsightedness, argues that it will relieve us from the necessity of maintaining a navy. He states at length the power of the English Navy, and the expense of maintaining it; showing, also, that our trade with England furnishes her with funds to support a navy. He admits that navies will continue to exist, but argues that his system of torpedo defense will prevent them from oppressing the United States, neglecting entirely the protection of our mercantile marine. F. T. B.

REVIEWS.

REPORT OF THE SUPERINTENDENT OF THE U. S. COAST AND GEODETIC SURVEY, SHOWING THE PROGRESS OF THE WORK DURING THE FISCAL YEAR ENDING WITH JUNE, 1884.

This report contains, with other matters, a detailed account of the work performed during the year ending with June, 1884, by officers of the Navy attached to the Coast Survey, together with a cordial acknowledgment by the Superintendent of the value of these services. It appears that, in accordance with the law which authorizes the employment of naval officers in the Coast Survey, there were employed in this service, during the year above indicated, one Commander, three Lieutenant-Commanders, twenty-three Lieutenants, forty-four Ensigns, eight P. A. Surgeons, one Assistant Surgeon, one P. A. Paymaster, and six P. A. Engineers, making a total of eighty-seven officers. The work done by the Navy was principally hydrographic work, and on this duty eleven steamers and twelve schooners were engaged. These vessels were all commanded by naval officers and manned by sailors detailed from the Navy.

The aggregate amount of work performed by this force, which was divided into twenty-four parties, was as follows: Number of soundings taken, 481,008; area sounded in square miles, 4631; number of miles run while sounding, 12,846.

The hydrographic work of the Coast Survey was under the general charge of Commander C. M. Chester, assisted by Lieutenants Pillsbury and Moser. The steamer Blake, Lieutenant-Commander W. H. Brownson commanding, was employed in making hydrographic examinations in Vineyard Sound and on Nantucket Shoals, and in hydrographic work in Long Island Sound. The steamer A. D. Bache, Lieutenant H. B. Mansfield commanding, was engaged in resurveying the approaches to New York, and in new surveys on the west coast of Florida. The steamer Hassler, Lieutenant-Commander H. E. Nichols commanding, made a hydrographic reconnaissance of the bays and harbors of Southeastern Alaska, and afterwards, under the command of Lieutenant-Commander A. S. Snow, a hydrographic survey of the Strait of Fuca, W. T.

The other important hydrographic work performed was as follows: Surveys between Cross Island and Nash Island, and in Narragugus Bay and River, coast of Maine; numerous surveys in Long Island Sound, Delaware Bay, Chesapeake Bay, south branch of the Elizabeth River, and on the coasts of Louisiana and Texas. On the Pacific Coast, a survey of the vicinity of Point Buchon, California, and an examination of the bar at the entrance to San Francisco Bay were made; and also surveys at other points on the coasts of California and Washington Territory.

In addition to the work above mentioned, Lieutenant Pillsbury made numerous hydrographic examinations along our Eastern and Southern Coasts as a preparation for the revision of the *Atlantic Coast Pilot*. Lieutenant Fremont made a number of current observations off New York entrance and on the east coast of Florida.

Commander Chester, assisted by Lieutenant Clover, superintended the construction of the U. S. Coast and Geodetic-Survey steamer Carlisle P. Patterson, a vessel intended for service on the Pacific Coast.

The above record of hydrographic work is an account of the service of naval officers in the Coast Survey for a single year. The work is continued from year to year, and as discoveries are made affecting the navigation of our coasts they are immediately reported to the Coast-Survey Office at Washington, and the necessary information regarding them is issued to seamen at once by the Superintendent of the Coast Survey. It is evident that, owing to the constant changes which are taking place in all the harbors and other water-ways along our coasts, this service is indispensable to the safety of our commerce. The Superintendent of the Coast Survey has very justly given credit to naval officers for the faithful performance of this important duty.

B. F. T.

BIBLIOGRAPHIC NOTES.

AMERICAN GEOGRAPHICAL SOCIETY, BULLETIN No. 2, 1885.

John Cabot's Landfall, Site of Norumbega, by Prof. E. N. Horsford, of Cambridge.

An interesting and thorough study of the subject, accompanied by a set of heliotype maps and sketches.

Conclusions: 1st. That the site of the Landfall of John Cabot in 1497 has been determined to be Salem Neck, in latitude 42° 32′ N.; the Norum (the Neck, to one standing on it) of the Norumbega of Cabot, and the Nahum of the Nahumbeak of Ogilby and Smith. The first land seen may have been Cape Ann, or possibly the mountain Agamenticus.

2d. That the town of Norumbegue, the fort of that name, and the village of Agoncy, were on the Charles River, between Riverside and Waltham, in latitude 42° 21′ N. (Middlesex Co., Mass.).

3d. That John Cabot preceded Columbus in the discovery of America.

Life and Scenery in the Far North, by Wm. Bradford.

A graphic description of a summer trip to the west coast of Greenland in the steam sealer Panther (450 tons), described as having a sheathing of Australian ironwood 4 inches thick over her usual planking of 5 inches thickness; her stern was sheathed with heavy boiler iron; forward she was sheathed and built up solid for 12 feet abaft the stem; inside she was supported by heavy oak beams placed at every ten feet to resist transverse pressure. The paper gives an interesting account of the ice-navigation, scenery and native customs of the west coast. J. W. D.

AMERICAN SOCIETY OF CIVIL ENGINEERS, TRANSACTIONS.

OCTOBER, 1885. New method of making conventional signs on original topographical maps, by J. A. Ockerson.

The great saving in time and expense, also the even quality of the work produced, should recommend this new method to draughtsmen, the Naval Service and the Coast Survey.

If the appropriate rollers and outfit were supplied to surveying vessels, the draughtsman could put in the outlines of the maps, water-courses, roads, etc., while any officer attached to the vessel could, after a little practice, print in the conventional signs, lettering and soundings. W. P. C.

ANNALEN DER HYDROGRAPHIE.

PART X. Cruise of the Niobe on the coasts of Norway, England and Scotland. Tidal and weather information. Cruise of the Asia on the Pacific Coast of Central America. Description of a pampero in the South Atlantic. International lighthouses.

PART XI. Best determination of observation-point from altitudes of a star. The German gunboat Iltis in the Min River. Deep-sea

soundings in the Gulf Stream and on the east coast of North America; a résumé of the work of the Albatross.

PART XII. Cruise of the German corvette Bismarck on the west coast of Africa. The climate of Port Stanley and the Falkland Islands.

CRUISE OF THE AUSTRIAN CORVETTE AURORA TO BRAZIL AND THE LA PLATA IN 1884–1885.

CRUISE OF THE AUSTRIAN CORVETTE FRUNDSBERG IN THE RED SEA AND ON THE EAST COAST OF AFRICA IN 1884–1885, published by the Mittheilungen a. d. Gebiete d. Seewesens.

A small part of these volumes is devoted to a brief sketch of the vessel's cruise and of the ports visited; then follows an immense amount of statistical and commercial information in regard to the countries visited. This information is of the most minute character, and cannot fail to be of great value.

J. T. S.

ENGINEER.

JANUARY 1, 1886.

In the annual review of engineering progress, under the head of "Mechanical Engineering," it is stated that no decided advance has taken place in marine work during the past year, and nothing is now heard of the great pressures, such as 160 pounds, 180 pounds, and even 200 pounds, talked about this time a year ago. It seems generally accepted as proved that nothing is gained by going beyond 150 pounds. Some quadruple-expansion engines have been tried. The results have not been encouraging. They are in no sense better than those obtained from triple-expansion. The triple-expansion engine has proved itself to be just so much more economical than the ordinary compound that its use covers the whole cost of insurance, and in certain cases gives a margin besides. Two-cylinder compound engines are being rapidly and completely superseded by the triple engine, as they superseded the low-pressure engine and jet condenser. If business in the shipping world would get a little better, plenty of work would be found for engineers in converting the existing double-cylinder engines into triple engines.

In the mercantile marine no advance has been made in the adoption of forced draught. In the Navy, on the contrary, forced draught is becoming the rule instead of the exception. The method adopted is to enclose the fire room, in order to put it under pressure, by getting a horizontal ceiling about ten feet above the floor plates, extending from the coal-bunker bulkheads to the front of the boilers, and from this ceiling vertical screen plates are carried down between and at the ends to meet the front boiler-bearers. By this means the fire room proper can be readily converted into closed, air-tight chambers of comparatively small dimensions. The first ships of the Navy to which this system was applied were the Satellite and Conqueror. During a four hours' trial the Satellite, with natural draught, developed 10.15 I. H. P. per square foot of grate; with an air pressure of 1¼ to 2 inches of water in the fire room the power rose to 16.9 I. H. P. In the Conqueror natural draught gave 8 I. H. P. per square foot of grate, and forced draught 16.46. In the trial of the ironclad Rodney last year an air pressure of 2 in. gave 17.3 I. H. P. per square foot of grate. It may be taken as proved, therefore, that an air pressure of 2 inches of water in fire room will augment the boiler efficiency by 70 per cent. This augmentation also permits a great saving to be made in the weight of boilers and machinery. With forced draught an indicated horse-power can be obtained from two cwts. of machinery.

January 8. Liquid Fuel.

For some time past experiments have been made at Portsmouth Dockyard on petroleum as fuel. A method of burning creosote, patented by Col. Sadler, is being tested there. It seems that the boiler used will evaporate ten pounds of water per pound of coal burned. With creosote as fuel the ratio becomes one to thirteen, the pressure being 60 pounds. Many attempts have been made to use mineral oils as fuel, but none of them have resulted in commercial success. Mr. Ayrdon was the first engineer who succeeded in this country in burning liquid fuel in a steam boiler. He effected his object by injecting the fuel in the form of spray by the aid of a jet of steam; and nothing to rival this system has ever been discovered.

An average sample of petroleum contains—carbon, 85 per cent.; hydrogen, 13 per cent.; and oxygen, 2 per cent. Its calorific value is very high, because of the large quantity of hydrogen. Petroleum will evaporate theoretically about 18 pounds of water per pound of oil. Its calorific value may be taken as two and a half times that of coal, while the value of the crude oil is a little less than twice that of coal. In practice, however, no such results have ever been obtained; and, because attention is being once more directed to the subject and hopes may be formed which cannot be realized, it is well that something should be said of the practical difficulties which stand in the way. Since petroleum is about twice as dear as coal, it must be twice as efficient, to be burned with equal economy; but a practical evaporation of 20 pounds of water per pound of petroleum has never been obtained. Petroleum is a very difficult thing to burn to advantage, because of the enormous amount of smoke which it produces. The smoke itself does not necessarily represent much loss of fuel, but the deposited soot does, because it coats the heating surfaces with an admirable non-conductor. To prevent smoke, the fuel must be burned with a large supply of air in a brick-lined chamber, which will prevent the rapid cooling of the gas and partial extinction of the flame. This entails a very important modification in the structure of a boiler, and any attempt to use petroleum in existing marine boilers practically deprives them of the heating surface of the furnaces, because these must be lined with fire-brick if the combustion is to be complete. It appears certain that the total efficiency of a marine boiler burning liquid fuel must be lowered. This is a simple deduction from theoretical considerations, but it has hitherto been borne out in practice, for the Himalaya, the steamer which recently made a run to Leith with liquid fuel, could not keep steam to anything near the proper pressure, and the experiments made at Portsmouth have so far ended the same way.

A serious objection to the use of liquid fuel is that a very considerable quantity of steam is required to blow the fuel in the furnace. This steam acts on the fuel precisely as it would on water in an injector. It is condensed and enters the furnace as so much water, which has all to be re-evaporated. The quantity used has never been ascertained with any exactness, but it is of importance. With long voyages and high pressures, steam would have to be furnished by a supplementary boiler working with salt water at a low pressure, or else special distilling apparatus must be provided to furnish fresh water to the main boilers. This is a second and very serious obstacle to the use of liquid fuel at sea.

The great merit claimed for liquid fuel is that a smaller quantity of it than of coal may be carried, or that a given weight would take a ship much farther than would a similar quantity of coal. Bulk for bulk, liquid fuel will occupy as much space as coal. If, however, it can be shown that a ton of liquid fuel will do as much as a ton and a half of coal, then space may be saved or the duration of cruises prolonged. It may also be urged, and with justice, that the number of hands in the fire room may be reduced. In the mercantile marine petroleum has no chance whatever: the price must always prove fatal to its success. In the Navy, price is a secondary consideration; but it must not

be forgotten that even a small shell exploded in a mineral-oil tank would produce the most appalling results.

The principal point to be decided is, however, the possibility of burning the oil to advantage at sea. This has yet to be proved. Until this is done, it is useless to point out objections to the use of a comparatively volatile, inflammable fluid as fuel.

JANUARY 29. The U. S. S. Chicago.

In an editorial on the subject of the Chicago's boilers and engines, the following opinions are expressed: "The design of the machinery has undergone important modifications, but the principal objectionable features have been perpetuated, and we are in some doubt as to which design is the worst. There was ample space in the ship for horizontal engines, but her designers have used beam engines; why, it is very difficult to explain. The ship is unarmored, and it was therefore desirable to keep her machinery as far below the water line as possible. As the crank shaft stands about four feet above the level of the floor plates, no difficulty would have been experienced in putting horizontal engines in with low-pressure cylinders 78 inches in diameter, and the entire height of engines need not have exceeded 10 feet. The engine room of the Chicago, with its four working beams, will present a sight which will strike English eyes as archaic. Concerning the proportions of parts adopted little need be said. Things seem to have been made big enough and heavy enough. Yet we doubt that 14½ inches is a sufficient diameter for the crank pins, and if the main centres of the beams do not give trouble when the ship is in a seaway, we shall be much surprised.

"The engines are enormously heavy, not less than 3.32 cwts. per indicated horse-power, which is much in excess of the results obtained in the British Navy.

"The boilers are of worse design than the engines, and will no doubt be pulled out after a cruise or two. Criticism sufficed to produce a departure from the original design, but it has not made matters any better. The grates are of the most unwieldy dimensions, being no less than 8 feet wide by 7 feet long. So much doubt has been expressed concerning the power of the boilers to furnish dry steam, that a superheater has been added, which cannot be used when the ship is going into action—that is to say, just when dry steam will be most wanted. The superheater seems to have been specially constructed to do the greatest possible harm when it explodes, as it is sure to do some day. In looking over the drawings of this machinery, we see the results of all the experience laboriously and expensively acquired in this country cast to the winds, and a design which is only not experimental because it is a relic of the past, vamped up and made to do duty as something new." J. K. B.

FRANKLIN INSTITUTE JOURNAL.

DECEMBER, 1885. Scientific Method in Mechanical Engineering.

An introductory lecture to the Course on Mechanics at the Franklin Institute, by Mr. Coleman Sellers.

The Tatham Dynamometer, by W. P. Tatham.

JANUARY, 1886. Electricity in Warfare.

A lecture delivered before the Franklin Institute, illustrating the various applications of electricity in warfare, by Lieutenant B. A. Fiske, U. S. N.

Steam-Vessel Indicator. Novelty Electric Works. Philad.

J. K. B.

GIORNALE D'ARTIGLIERIA E GENIO.

Nos. IX. and X. of 1885. Official descriptions and working drawings of various implements of the Artillery and Engineers.

R. C. S.

JOURNAL DU MATELOT.

No. 46, 1885.

Notwithstanding the many advantages presented by hydraulic-propulsion torpedo boats, it does not seem at all probable that they will replace those driven by screws, as they disturb the water to such an extent that they can easily be detected with a glass at a distance of a thousand yards on a clear night, and, if the sea be phosphorescent, at double the distance, if not farther.

C. B.

MECHANICAL ENGINEER.

NOVEMBER 28, 1885. The U. S. S. Chicago.

A full description with detailed dimensions of the hull, boilers, engines and auxiliary machinery of the cruiser Chicago, illustrated by four large cuts; and a valuable article on twin-screw naval cruisers, containing the general dimensions of the principal foreign unarmored cruisers now under construction, and the performance of those recently finished.

DECEMBER 12. Forced Combustion.

An article descriptive of the various methods that have been tried for inducing an increased draught by artificial means, together with a comparative table showing the coal burnt per square foot of grate, and indicated horse-power per square foot of grate developed by modern vessels of war under natural and the different methods of forced combustion.

Compression.

A mathematical investigation into the subject of compression in steam cylinders, with the object of showing when compression is useful and when disadvantageous. By Sven Brunau, M. E., Sweden.

JANUARY 9, 1886. Wheeler's Improved Surface Condenser.

In this condenser the tubes are entirely independent in regard to endwise expansion: they can expand freely without detriment to themselves or any other parts. They are free from tube ferrules or packing of any kind; having a screwed connection with the tube sheets, the exhaust steam enters above the tubes in the upper part of condenser, passes over a scattering plate, preventing the steam impinging upon the tubes. The upper part of condenser above the scattering plate is large; the pressure and temperature of the steam are consequently reduced to some extent by expansion before striking the cold tubes. The tube arrangement is as follows: A small tube is expanded into a screw head, which latter screws into the front tube sheet. A short distance from this sheet is a second tube sheet, into which a larger tube is screwed, the tube end being drawn thick to permit of its being threaded. The small tube passes into the larger and ends within a few inches of a screwed cap closing the outer end of the large tube, giving ample space for the water to reverse its direction before flowing back through the annular space between the two tubes. The injection water is pumped into the compartment between the front tube sheet and condenser bonnet, passing through small inner tubes, returns around them through the outer ones, and discharges into the compartment between the first and second tube sheets and leaves the condenser through the outboard discharge valve. Whenever it is necessary to remove the tubes for cleaning, etc., both small and large tubes can be drawn out from the same end of the con-

denser, as the screw-head into which the small tube is expanded is larger than the thickest part of the large tube.

The Lighthall Manufacturing Company claim that by carefully conducted tests these condensers have shown 200 pounds condensed steam per hour per square foot of condensing surface.

[It would be well to state, in connection with this latter statement, that in the experiments made by Joule it was found that by carrying the injection from 68° to 77° only 100 pounds per square foot of cooling surface could be condensed under very favorable conditions, while in practice with compound engines, using composition condenser tubes, 15 pounds steam per square foot of condensing surface is considered excellent work.

Under these circumstances, it would appear that the claim made for the Wheeler condenser is rather in excess.—EDITORS.]

Screw Propellers of the Boston and Atlanta.

A description of the screws fitted to the above vessels, with a method of laying down a Hirsch screw propeller for any given vessel.

MARCH 6. Comparative Performance of Merchant Steamers.

Tables containing the principal dimensions and average performances of a number of leading vessels in the English merchant marine, together with a method of laying down the curves of speed and power of steamships.

J. K. B.

MITTHEILUNGEN A. D. GEBIETE D. SEEWESENS.

VOL. XIII. NO. IX. Historical sketch of the development of nautical instruments for measuring angles. English evolutionary squadron in 1885. Translation of Lieutenant Ingersoll's paper, Corrections for wind, etc., which appeared in No. 33, Proceedings of the Naval Institute. English Navy. Trial of the Rodney's Machinery. Torpedoes. French Navy. Sinking of two torpedo boats and of the dispatch vessel Renard. Russian Navy. Use of naphtha as fuel for torpedo boats. Italian Navy. The armorclad Lepanto. New torpedo boats for Germany and China.

Nos. X. and XI. The works on naval warfare of the future. The manœuvres of the Italian Practice Squadron in 1885 (with chart). The Moncrieff-Laffete system for Russian ironclads. The English Navy. Torpedo boat Grasshopper. The Brotherhood system of steam-steering machinery. Electric lighting on board ship. Trial of the Impérieuse. The Berdan torpedo. The Nordenfeldt submarine torpedo boat.

J. T. S.

NORSK TIDSSKRIFFT FOR SOVAESEN. HORTEN, NORWAY.

Numbers 1, 2 and 3 of the 4th year of the Norwegian *Maritime Journal* have been received.

No. 1 contains an account of the capture of the Pescadores Islands by the French in the Franco-Chinese War, written by Premier Lieutenant Rosenquist. The article contains a map and full details of the operations.

The second article is a paper by Captain Gasmann, "Armored or Unarmored." This essay is a study and a compilation from *Journal of the Royal United Service Institution;* the article "Étude sur les combats livrés sur mer de 1860 à 1880," in the *Revue Maritime et Coloniale* for 1881; the article "La réforme de la Marine," from *Revue des deux Mondes*, 1884, and "Das Torpedo Gagdshiff," from the *Mittheilungen aus dem Gebiete des Seewesens*, translated from *Rivista Marittima.* The paper is concluded in No. 2, and

introduces all the elements which render the question of the value of armor so complicated.

There is a short résumé of an article on "International Lights and Lighthouses," from *Shipping Gazette and Lloyd's List Weekly Summary*. This is followed by a complete descriptive list of all the vessels of the Swedish Navy. All the particulars of each and every ship are given in tabulated form. The "Miscellaneous" chapter contains short articles on "The Torpedo Chaser," "New American Cruisers" (additional vessels), the new electric boat Volta, and an account of Nordenfeldt's submarine boat taken from the *Broad Arrow*. The remainder is taken up with official intelligence, movements of officers, general orders, etc.

The second number of the fourth year contains the conclusion of Captain Gasmann's essay, "Armored or Unarmored." "Day Signals," from the *Weekly Summary Lloyd's List*. A complete descriptive list of all the vessels of the Norwegian Navy, with all the particulars of each and every vessel in tabulated form. An article on Lighthouse Illuminants, with the conclusions of the Trinity House Committee on the relative merits of electricity, gas and oil.

The "Miscellaneous" chapter contains articles on the Dynamite Gun, from *Scientific American* of October 24th, 1884. An account of a novel steamboat, from the same paper. This is a steam catamaran; the two cigar-shaped floats have screws which are revolved by a steam engine placed on a superstructure over the floats. A short article "Defense against Torpedoes," from the *Broad Arrow*, is especially interesting in connection with Captain Gasmann's essay. The chapter closes with a brief account of the progress of torpedo-boat building in Germany by the firm of F. Schichan & Co. at Elbing. The usual official intelligence concerning movements of officers, general orders, etc., concludes the number.

The 3d number of the 4th year has the following contents: "Coast Defense at Home and Abroad," by Reserve Lieutenant Müller. This article quotes that entitled "The Defense of Our Coasts," from *Engineering* of May 1, 1885, and discusses the condition of the Norwegian coast defenses, and measures necessary to defend them and their approaches.

The second article is a translation of Captain Galwey's paper, "The Use of Torpedoes in War," from the *Royal United Service Institution*. Then follow: "Liquid Fuel," from *Nautical Magazine*. "The Lighting of the Suez Canal," from *Weekly Summary*, giving the recent regulations allowing men-of-war and mail steamers having electric lights to navigate certain portions of the canal at night.

The "Miscellaneous" chapter contains: An article on "Experiments with Machine Guns," from *Army and Navy Gazette*. The definition of a ton. "A Torpedo Chaser," from *Engineering* of Nov. 27, 1885. Description of Goubet's submarine boat, from *Engineering* of Nov. 20, 1885. A brief notice of the "Effect of Electricity upon Ships' Compasses," with certain precautions to be taken. The number concludes with the usual official intelligence.

W. H. B.

REVUE MARITIME ET COLONIALE.

DECEMBER, 1885.

This number of the *Revue* contains an article by M. Besson, Enseigne de vaisseau in the French Navy, describing an apparatus for illuminating the vernier and limb of a sextant in order to facilitate reading the instrument at night. The apparatus consists of a very small incandescent electric light which is attached to the index bar. The electricity is supplied by a small battery in which bichromate of potash is used, and the battery is arranged to act only at the will of the observer.

The practical difficulty in employing such an apparatus is with the battery.

Unless the plates are carefully cleaned every time it is used, they become polarized very rapidly, and are soon unfit for use. On account of the labor involved in taking care of the battery, it is doubtful if the apparatus will prove of any practical value. The excellent bull's-eye lantern which is supplied in our service answers every purpose for night observations, where the difficulty is not in reading the instrument, but in discerning the horizon clearly.

French swift cruiser Taze, building on the Loire.

To be of steel, twin screws, and protected by an armored deck. Length between perpendiculars 389 ft. 6 in., extreme breadth 53 ft. 9 in., depth 35 ft. 11 in., mean draught 19 ft. 9 in., difference of draught 3 ft. 7 in., displacement 7045 tons. Besides the usual division into compartments, a cellulose belt will aid the floatability. The screws will be driven by independent, three-cylinder, horizontal engines; to develop, with natural draught, 8115 H. P.; with forced draught, 10,330 H. P. She is to have nine auxiliary engines to work pumps, ventilating apparatus, etc. The boilers to be in three independent groups, four cylindrical boilers in each group. To carry fourteen hand pumps for various purposes, and in addition two steam pumps capable of discharging 1000 tons of water an hour and a third pump capable of discharging 90 tons an hour, intended principally to discharge the water ballast. She will be lighted entirely by electricity. To be armed with six 6.26-in. on the forward and after parts, ten 5.57-in. in battery, three 1.84-in. rapid-firing guns and twelve Hotchkiss 1.45-in. cannon revolvers; and to carry seven Whitehead torpedo tubes above the water line.

The speed of the Taze is expected to be 19 knots. She is to have three masts. Total cost, 8,750,000 francs; 3,500,000 for engines and boilers.

Russian ironclad Admiral Nakhimoff.

Launched October 22, on the Neva. The most powerful man-of-war built in Russia with native iron and steel. Dimensions: length 360 ft. 10 in., breadth 61 ft., draught 22 ft. 35 in., displacement 7781 tons. Engines to develop 8000 H. P.; speed 16 knots. Armament: eight long, VIII-in. cannon in the turrets; ten VI-in., and tubes for discharging torpedoes. Armor 7.93 in. at the water line, and 9.8 in. at the turrets. B. F. T.

ROYAL UNITED SERVICE INSTITUTION JOURNAL.

No. CXXX. Liquid Fuel for Marine Purposes, by Vice-Admiral Selwyn, R. N.

The advantages of liquid fuel are briefly stated: "To burn liquid fuel instead of coal requires no change in engines or boilers, and only such an adaptation of the furnaces as can be readily carried out in each ship by her own artificers and engineers; at the same time, it removes the necessity of a whole army of stokers and coal trimmers. It enables a ship to receive her fuel with the greatest facility at sea or in harbor, while proceeding under steam or even sail, is without the nuisance of dust or ashes, and it is not liable either to spontaneous combustion or to deterioration by time, heat or moisture. If the ship gets on shore, it can be run out to lighten her, or be pumped out into lighters with a speed and facility unapproachable with coal; and, lastly, if, as I believe, 46 pounds of water can be evaporated with one pound of fuel, full steaming for *twenty-four* days can be carried on where now we are limited to *four*." This high calorific power is obtained by blowing a jet of steam into the burning oil, when separation taking place, combines some of the hydrogen of the steam with the ignited hydrocarbons. Admiral Selwyn further believes that "in any future war England must either again destroy her enemies' goods —wherever found at sea, under whatever flag—or submit to lose her own commerce, and with it the power of feeding her population. There is no alterna-

tive, and therefore no choice. To carry this out, no condition is more important than increased fuel and better economies of fuel." C. B.

RIVISTA DI ARTIGLIERIA E GENIO.

OCTOBER, 1885. Solutions of problems relating to the trajectory. Rotation of projectiles. Range tables for coast batteries (elevation of battery considered).

An electric small-arm target.

Shows position of hits on a signal disk near the marksman.

NOVEMBER. The small-arm trajectory. The Spezia experiments of October, 1884 (from report of commission).

R. C. S.

RIVISTA MARITTIMA.

OCTOBER–NOVEMBER, 1885. The Italian Navy Estimates (continuation).

R. C. S.

UNITED SERVICE GAZETTE.

OCTOBER 3, 1885. The Severn.

An unarmored fast steel cruiser belonging to the Mersey class; was launched September 29th at Chatham; is 300 feet long between perpendiculars, 46 feet beam, 17 feet 9 inches draught of water, displacement 3600 tons. The engines are horizontal; the I. H. P., 6000; twin screws, estimated speed 17½ knots. The coal capacity is 500 tons; crew, 300; armament, two 8-inch and ten 6-inch B. L. R., one 9-pounder and one 7-pounder boat guns; six 1-inch Nordenfeldts, two Gardners, together with Whitehead torpedoes. The principle followed in the construction has been that of a water-tight hull, and to guard the boilers, engines and magazines as far as possible from danger. She has been two years building, and her cost is about $775,000.

OCTOBER 10. The Hecla.

This torpedo store-ship, having been fitted with a new and smaller screw, was tested, with a result showing an increase of speed from 10.25 to 13.24 knots. This appears to be due to the new screw being proportioned to the steam-producing capacity of the boilers; the I. H. P. showed an increase of 47 per cent. and the speed 13 percent.

OCTOBER 17. Rule of the Road.

Adm. Heath disapproves of Capt. Colomb's advice that when a green light of an approaching steamer is seen slightly on the starboard bow, the course of the ship should not be changed until it is beyond doubt that the two vessels will pass each other to starboard. And another officer writes that Adm. Heath takes a very erroneous view of the question, and that the admiral's advice to starboard the helm three points in the above case is most dangerous, for the officer in charge of the other vessel may see the three lights of the first vessel and put his helm to port at the same moment. The plan recommended by this officer, when a green light is sighted ahead or a little on the starboard bow, is to watch it closely and to signal to stand by in the engine room; so that if the stranger suddenly ports, the ship may be stopped and sent full speed astern and the action signalled at the same time by the whistle. When so much difference of opinion exists in a case of such common occurrence, some definite line of action should be authoritatively enunciated.

The Admiralty have acquired Horsea Island, at the head of Portsmouth Harbor, and are about to spend something over a million dollars on it as a torpedo supply and experimental station. A canal 1000 yards long is to be made as a torpedo range.

Liquid Fuel.

Admiral Selwyn shows that a given steamer burning 300 tons of coal a day for a given speed would require only one-sixth of that quantity of oil to do the same work. Allowing for the difference in cost of coal and oil, there would be a large saving in the cost of fuel in a ten-days' trip, to say nothing of the cost of firemen's wages, provision, firing tools, etc. Additional cargo space would be gained, which would still more increase the balance in favor of oil.

October 31.

The armor-plated ship Hero was launched on the 27th inst. at Chatham. She is 270 feet long, 58 feet beam, 6200 tons displacement, 6000 H. P., and will carry two 12-inch 43-ton B. L. R. in turret, four 6-inch 4½-ton B. L. R. on the sponsons, seven 6-pounders, one 9-pounder and two 7-pounder boat guns, one 9-pounder field gun, seven 1-inch, 4-barrel Nordenfeldts, two 0.45-inch, 5-barrel Gardners, and Whitehead torpedoes.

On the same day was launched at Sheerness the Swallow, the first of a new class of fast, heavily-armed gun vessels which will carry eight 5-inch steel B. L. R., eight machine guns and spar torpedoes. She is 208 feet long, 27 feet beam, 1040 tons displacement, and 1500 H. P.

November 28.

In order to encourage English naval officers serving on the East India station in acquiring a knowledge of Persian, Hindustani and Arabic, the Indian Government offers gratuities for passing examinations in these languages. After being qualified, the officer receives a monthly pay of 50 or 100 rupees as interpreter for the ship upon which he is serving, and if the ship be ordered home, he may be transferred to another on the station when practicable.

December 5. The Thames.

This schooner-rigged steam cruiser was launched 3d inst. She is built entirely of steel, is 300 ft. long, 46 ft. beam, 3500 tons displacement, and draws 16 ft. forward and 20 ft. aft. She has twin screws, and compound engines with surface condensers; with natural draught the I. H. P. will be 3800; with forced, 5700; the estimated speed is 17 knots. She will carry two 8-in. and six 6-in. guns on Vavasseur central-pivot carriages; six 6-in. broadside; three 6-pdr. rapid-firing guns; six 1-in. 4-barrel Nordenfeldts; two 0.45-in. 5-barrel Gardners, and eighteen Whitehead torpedoes; two electric search lights; 750 tons coal and 300 officers and men. The total cost will be about $750,000.

December 19. Liquid Fuel.

The system of Col. Sadler is now undergoing trial at Portsmouth. The fuel consists of creosote which costs two cents a gallon; it is kept in a tank at a uniform temperature and consistency by steam coils inside the tank, and forced into the furnaces by steam injectors. So far the system has proved superior to others previously tried. C. B.

NOTICE.

The Prize Essay for 1886, as awarded in the following letter, and the discussion thereon, will be published in WHOLE NO. 38, PROCEEDINGS OF THE U. S. NAVAL INSTITUTE. A few copies of the essay have been printed and sent to the various Branches for distribution, the object being to invite a general discussion of the subject. The Board of Control, therefore, request that the said essay may be read and discussed at each Branch not later than May 12, 1886. The Corresponding Secretaries will please collect all MSS of the discussion at their respective Branches, and forward them for publication to the EDITING COMMITTEE before May 25, 1886.

CHAS. R. MILES,
J. K. BARTON,
Editing Committee.

NAVY DEPARTMENT, *Washington, D. C.*,
February 18, 1886.

LIEUT. J. W. DANENHOWER, U. S. Navy,
Secretary U. S. Naval Institute.

Sir:—The undersigned have had under consideration the seven essays submitted to them by the Board of Control of the Naval Institute for judgment upon their relative merits.

We award the prize to the paper bearing the motto "Scire quod nescias," * and we consider as worthy of honorable mention the two papers bearing respectively the mottoes "Consilio et animis" † and "The result of all naval administration and effort finds its expression in good organization and thorough drill on board of suitable ships," ‡ in the order named.

We desire to be understood as not necessarily endorsing all the views that are presented either in the prize or the other essays.

Very respectfully,

E. SIMPSON,
Rear-Admiral, U. S. Navy.
MONTGOMERY SICARD,
Captain, U. S. N.
A. P. COOKE,
Captain, U. S. N.

* Lieut. Carlos G. Calkins, U. S. N. † Commander Caspar F. Goodrich, U. S. N
‡ Ensign W. L. Rodgers, U. S. N.

SPECIAL NOTICE.

NAVAL INSTITUTE PRIZE ESSAY, 1887.

A prize of one hundred dollars and a gold medal is offered by the Naval Institute for the best Essay presented, subject to the following rules :

1. Competition for the Prize is open to all members, Regular, Life, Honorary, and Associate, and to all persons entitled to become members, provided such membership be completed before the submission of the Essay. Members whose dues are two years in arrears are not eligible to compete for the Prize until their dues are paid.

2. Each competitor to send his essay in a sealed envelope to the Secretary and Treasurer on or before January 1, 1887. The name of the writer shall not be given in this envelope, but instead thereof a motto. Accompanying the essay a separate sealed envelope will be sent to the Secretary and Treasurer, with the motto on the outside and writer's name and motto inside. This envelope is not to be opened until after the decision of the Judges.

3. The Judges to be three gentlemen of eminent professional attainments (to be selected by the Board of Control), who will be requested to designate the essay, if any, worthy of the Prize, and, also, those deserving honorable mention, in the order of their merit.

4. The successful essay to be published in the Proceedings of the Institute; and the essays of other competitors, receiving honorable mention, to be published also, at the discretion of the Board of Control ; and no change shall be made in the text of any competitive essay, published in the Proceedings of the Institute, after it leaves the hands of the Judges.

5. Any essay not having received honorable mention, to be published only with the consent of the author.

6. The subject for the Prize Essay is, *The Naval Brigade : Its Organization, Equipment, and Tactics.*

7. The successful competitor will be made a Life Member of the Institute.

8. In the event of the Prize being awarded to the winner of a previous year, a gold clasp, suitably engraved, will be given in lieu of a gold medal.

By direction of Board of Control.

JNO. W. DANENHOWER,
Lieutenant, Secretary and Treasurer

ANNAPOLIS, MD., *January* 1, 1886.

Vol. XII., No. 3. 1886. Whole No. 38.

PROCEEDINGS

OF THE

UNITED STATES

NAVAL INSTITUTE.

VOLUME XII.

PUBLISHED QUARTERLY BY THE INSTITUTE.
ANNAPOLIS, MD.

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BALTIMORE, MD.

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THE PROCEEDINGS

OF THE

UNITED STATES NAVAL INSTITUTE.

Vol. XII., No. 3. 1886. Whole No. 38.

U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

MAY 12, 1886.

CAPTAIN N. H. FARQUHAR, U. S. N., in the Chair.

PRIZE ESSAY FOR 1886.

Scire quod nescias.

WHAT CHANGES IN ORGANIZATION AND DRILL ARE NECESSARY TO SAIL AND FIGHT EFFECTIVELY OUR WAR SHIPS OF LATEST TYPE?

BY LIEUTENANT CARLOS G. CALKINS, U. S. N.

CONTENTS.

I.—Introduction.

The Naval Institute may be congratulated upon the strictly practical and professional nature of the subject now presented for discussion. Questions of policy or expenditure heretofore discussed may be left to be acted upon or ignored by Congress or the Cabinet. The work of naval officers cannot be extended or our shipping increased, except through the slow and uncertain action of public opinion as expressed in the press or in our national legislature. The question now before us is, however, one which only naval officers can discuss, and it is one which they cannot afford to ignore.

The frank statement of the question recognizes a fact of vital importance and supplies us with a fundamental proposition. Changes are necessary, both in organization and drill, if our ships are to be made effective men-of-war. There may be those who would denounce any proposition to sail our ships effectively in time of peace as unseamanlike, and any discussion of methods for fighting in time of war as theoretical. In spite of these damnatory adjectives, we must

undertake the treatment of this difficult but inspiriting subject, which appeals to the interest of every officer who believes in the future of our naval service or expects to share in the arduous work of sailing and fighting ships of modern type.

When we come to consider our vessels of modern type with a view to suggesting changes in drill and organization, we find that they are few in number, of moderate tonnage, and neither armed with the most formidable weapons now in use nor protected by armor. Their motive machinery has not escaped criticism, and their construction by contract has been attended with delays and difficulties. These facts must be noted without discussion, and we must proceed to ascertain and develop the capabilities of the ships now in progress.

The Chicago and Atlanta types are intelligent attempts to solve the problems of actual naval warfare. Within the limits of their size and cost they may be classed as fast and well-armed ships. The attempt has been made, for the first time since the Civil War, to give us ships that can fight under way. The ships are intended to have speed and handiness, and their batteries have been selected and disposed with a view to enable them to choose their distance and to fight without surrendering all the advantages of speed and manœuvring power. Vessels loaded with smooth-bore guns which can only be fired abeam, and hampered by unnecessary spars and rigging, can neither fight nor run away in action. A proper disposition of the battery and the complete subordination of sails to steam will enable our new cruisers to make a choice between these courses.

The successive Advisory Boards deserve the thanks of the service for their efforts to put an end to the period of reaction and paralysis which has lasted ever since the achievements of the Navy during the Civil War. Their designs are distinctly progressive, and a quarter of a century in advance of those of the last group of ships authorized by Congress. Ten years ago our constructors were allowed to copy the general plans of cruisers built before 1860 without effective protest from the service or criticism from the press. A slight gain in economy of coal was the only result of fifteen years of mechanical improvement. The partial success of the new cruisers will render such fatal errors impossible in future. Steam is accepted as the vital force for cruising as well as fighting.

These designs show evidence of a thorough study of the best foreign examples extant three years ago. Delays have enabled foreign builders to make a further advance and to reach higher speeds

than are claimed for the vessels built by those contracts made under the direction of the Advisory Board. The lapse of time and the activity of naval improvement are sufficient to account for this. But the attempt to make use of examples from abroad implies a definite amount of progress in the sentiments of the service.

The vague, pseudo-millennial anticipations of some naval officers and politicians can no longer secure recognition. Nations will not turn their Krupps into smooth-bores, their torpedo boats into pleasure yachts, and forget what they know about war, simply because we are content to put up with less than our money's worth and maintain our Navy on an inefficient basis. Moreover, we must remember that our next war will certainly be a foreign war, and that it will bring us into collision with an actual naval power. We ought to welcome the assurance that our foes will not be of our own household, and we ought not to dread the possibility of a conflict with a warlike and maritime nation. It would seem as though another civil war, or one of those wretched little wars peculiar to colonizing nations, were the only contingencies for which we attempt to be prepared.

The new cruisers and their successors for which plans are now in preparation are fortunate in the discussion which their construction has stimulated. It will prevent that neglect of practical detail which too often characterizes meritorious designs. It should also do away with the tendency to rely upon miraculous inventions to solve all our difficulties, which seems to be one of our national peculiarities. In most of the arts it may be said that the age of the inventor has been succeeded by that of the designer. Certainly all recent progress in the instruments and appliances of naval warfare confirms this opinion. The results of experiment and the principles of science must be put into practical shape by the capable designer. New inventions may be incorporated, but designs of ships of war must be established on careful study of the latest facts.

Besides the special naval types under discussion, we must include others in any scheme of naval organization. Our traditional naval policy will always compel us to rely upon the mercantile marine for material to put our Navy on a war-footing. This fact suggests the incorporation of a few selected steamers of the latest mercantile type in our cruising squadrons. Officers should be trained to handle such vessels, and modern armaments should be experimentally adapted for their use. If proper care were used in selecting the best types of ships built from year to year, the Government might obtain many

improved features in machinery and equipment, with opportunities for testing them with a view to their use in regularly constructed men-of-war. Steamers of 2000 tons register could carry two large torpedo boats, each with a full outfit, besides a light armament, and a large cargo of stores and coal for use on long voyages, or for issue to other vessels. Well-built and full-powered steamers of this class could be purchased for less than it often costs to repair an obsolete and inefficient wooden corvette, and they would perform the ordinary cruising duties of a man-of-war in time of peace more creditably and economically than any vessel designed twenty years ago. • Such vessels must be studied and recognized as types of auxiliary or torpedo cruisers for use in time of war. It is hardly necessary to recall the vast recent experiments in this direction carried on by the British Navy. Our present deficiencies emphasize the importance of this example. Not more than six such steamers would be required, and they should be sold as soon as they ceased to represent modern types. Such sales would not involve serious loss, if made within five or ten years after the vessels were built.

The attempt to discuss any question of burning importance to the naval service may involve the use of expressions which are lacking in respect for some venerable traditions and respectable prejudices. The form of the question is such that the answer will be nothing if not critical or comparative in its methods. Moreover, it is difficult to seek brevity and clearness without appearing to indulge in uncalled-for emphasis and assertion. If facts and details could be omitted and the exposition of fundamental principles substituted therefor, some of these dangers might be avoided.

This essay contains the present opinions of the writer, stated with as much frankness and clearness as he can command. He does not bind himself not to modify these opinions, nor does he predict their general acceptance and application in practice. The paper cannot come before its limited public without a signature, which must relieve the author from any imputation of posing as one having authority. It is hoped that these suggestions may be so clearly expressed and so kindly received that they will not be misunderstood by those who read them, or misinterpreted by those who do not care to take that trouble.

II.—Complement and Organization.

Some notice of the rules which should govern the allowance of officers and seamen to make up the complements of ships of modern

type must precede the discussion of plans of organization. The inevitable tendency towards replacing sails by steam might seem to promise a reduction in the number of men carried. Considering simple navigation as the work of a man-of-war, it might be practicable to follow the example of the mercantile marine in diminishing the proportion of crews to tonnage. Considering a ship as a military unit, we shall find that every improvement raises her fighting power and individual importance. The development of torpedo warfare and small-arm and machine-gun fire supplies employment for more men in action, besides multiplying occasions for detaching them for service on shore or in torpedo boats and steam launches. Ships cannot afford to deprive themselves of all power of manœuvring and defending themselves by detaching too large a proportion of their crews for military purposes, nor can they afford to miss occasions of rendering valuable service in emergencies. For these reasons they should have every mechanical appliance to save time and labor in getting under way and working ship and guns, and should have men enough to furnish parties for all kinds of detached service and reserves in action.

The complement of an efficient man-of-war should be fixed with a view to utilizing as many men as possible for attack and defense. It is not to be determined by counting the men required to man the great guns in her battery, nor does it depend upon the area of her sails, or the force required to handle them with primitive appliances. In fact, no arbitrary limits should be assigned. As many men as possible should be carried and trained to do their part in action. The practical basis for determining the complement is the berthing accommodation of the ship. Every improvement in lighting and ventilation can thus be made directly useful in promoting efficiency by obviating the disadvantages of large crews in contracted quarters.

There must not be a reduced complement in time of peace for the few ships of modern type which we can put in commission. Every one of them must be made a training-ship for all the men that can be carried. Modern ships and modern weapons must be utilized to afford real and practical training for modern warfare.

The complement of officers must vary with the number of the crew. While a small number of officers might suffice for navigating a ship on regular voyages, it is evident that an increase will be required if a large body of men are placed on board to be disciplined, instructed, and commanded in action. But tradition has its arbitrary standards,

and requires four watch-officers for all men-of-war. Strict watch duty must be carried on in gunboats of obsolete type and worthless armament, and officers must be detailed accordingly. This may leave only one or two more line officers in a ship carrying 500 men than are nominally employed with a crew of 30. Against such customs of the service it is the purpose of this essay to appeal. It is maintained that there is an essential relation between the number of officers and the fighting force of the ship. A further attempt will be made to give approximate rules for determining the proportion of officers and men. There must be a certain natural relation involved.

The engineer's force is charged with the work of furnishing the ship with motive power for use in action and on all occasions of emergency. It is therefore an essential part of the fighting organization and should have a liberal allowance of men. The working force should be sufficient for long passages under steam, and some provision for a reserve is also required. This reserve should be drawn from a contingent of landsmen forming part of the complement of every ship. They should be trained and drilled with the ordinary working and fighting force of the ship and encouraged to fit themselves for advancement to higher ratings, either as seamen or firemen, according to aptitude.

This brings up the question of recruiting, and may serve as an excuse for some discussion of its problems. The supply of continuous-service men trained in ships of war is not sufficient for our needs. By offering high wages in the open market we can get seamen quite equal to those who man the remaining ships of our unfortunate merchant marine. This class is, however, largely made up of foreigners.

It would be easy to exaggerate the disadvantages of this fact. The figures showing the nationality of any of our ships' companies would convey an unnecessarily alarming impression to most people. This is not a new or startling condition of things in the naval service of the United States. It is not, however, a condition with which we ought to be thoroughly satisfied, even in time of peace. In war it might give rise to serious inconveniences and complications. The inevitable failure of such a supply in time of urgent need can hardly be provided for. We could not then afford to train recruits whose first step must be the acquisition of the English language. Those we have trained may be relied upon as long as they are willing to remain in the service.

The naval-apprentice system is an attempt to Americanize the Navy by a supply of trained men for continuous service. The figures which should demonstrate the success or failure of this attempt are not available. Nevertheless, there is reason to believe that there has been a failure in its numerical results. It would be interesting to compare the number of graduates from our training ships, now serving as seamen or petty officers, with the total number of those who have been enlisted or who have passed through the prescribed course during the last ten years. If the percentage turned out to be inconsiderable as compared with the total number of seamen required for the Navy, it would be hard to justify the maintenance of the training squadron on its present basis, with its fleet of obsolete ships and its large staff of officers withdrawn from service under normal conditions, in ships of modern type and armament.

Consideration seems to show that we cannot with safety and propriety continue our reliance upon the mercantile marine for a supply of trained seamen, and that our apprentice system is slow and inadequate in its supply of continuous-service men. We are therefore thrown back on the source of supply which will be our inevitable dependence in time of war. Let us enlist young men of good physique and intelligence and give them a rapid course of military training while they are acquiring the rudiments of seamanship by serving in cruising vessels. France and Germany have their whole maritime population to draw naval recruits from, yet they are compelled to accept men from the general conscription, without regard to nautical experience. This element forms a respectable contingent on board men-of-war of those countries, and they show no marked inferiority when drilled with the merchant seamen and fishermen of the regular enrollment.

All these facts seem to favor the plan of enlisting men under 25 for general service with a view to their advancement, according to ability, after a practical course of training. They should be liable to discharge at the end of six months, at the discretion of commanding officers, if they are found unfit for the naval service. They should be trained in cruising vessels on the home station. Increased pay and privileges, as well as distinguishing marks in uniform, should be used as inducements to work and improvement. They should not be called landsmen. The naval use of this word implies tendencies to stupidity and stagnation which are not desirable. They might be designated as mariners, or naval volunteers, before advancement to

higher ratings. Their number should not exceed 25 per cent. of the complement of any seagoing vessel.

The training system should be kept up on a reduced basis to furnish trained men for special or technical work in connection with the armament and equipment of ships of modern type. Methods of training and principles of selection should be modified accordingly. The Government should in all cases reserve the right to get rid of bad bargains without waiting for the expiration of any fixed term.

The marine corps furnishes a valuable element in our ships' companies. Its services as a police force are invaluable, and justify its continuance in spite of the want of adaptability of its system of training to nautical conditions and modern weapons. These drawbacks are manifest enough to suggest the limitation of the marine guard of each ship to the smallest number which can be trusted to perform the strictly necessary sentry and police duties; otherwise they exclude men who might receive a thorough naval training from our few modern ships. It does not seem practicable to make any use of the nautical training and education possessed by the younger officers of the corps. The old routine restricts their usefulness, while their presence in small ships keeps out line officers who should be gaining experience and performing responsible duties.

The maintenance of strong marine battalions at two or three central stations would furnish the corps with opportunities for advanced military instruction, and the country with an organized force for detached service. From these battalions temporary details for guarding navy yards and public property could be readily made. Guards for ships should be made up of trained men only, who should receive a slight increase of pay for sea service. Two officers to each squadron would be sufficient to inspect and organize the marine guards of all the ships. Qualified sergeants and corporals should act as guides at battalion drills, and might serve as instructors for seamen in the manual and marksmanship where junior officers were wanting.

The recently established courses of instruction in ordnance for continuous-service men should provide the Navy with qualified instructors for the elements of gunnery and rifle practice. They should drill recruits under the direction of division officers, and the latter should be required to devote the time saved from drudgery to the advanced instruction of capable men.

It would be well to apply in this connection the principle of official

responsibility as the basis of all military organization. Petty officers of all grades must take their share of responsibility, and commissioned officers must be held responsible for results, while allowed to act for themselves in directing details and methods of training. Routine and regulations must leave something to be settled by commanding officers of ships and officers of divisions.

The watch bill is the foundation of our present system of drill and discipline. It is so ingenious and flexible in its methods that it can be adapted to ships of any class without essential modification. It should be given more continuous vitality by working and drilling its subdivisions, its watches and quarter watches, as active, organic units in port as well as at sea. Captains of parts of the ship should be supported and made to acquire a sense of responsibility for their men's presence and performance in answer to any call. Watches should be mustered daily in port, and parts of the ship should be preferred to mixed details in executing work of any kind. Organization and drill must combine to prevent the watch bill from losing its vital powers during a long stay in port. Work must be found for men in port to maintain physical training and discipline. But the force should be accurately proportioned to the work to be done, and the men designated must use their energies in working. Calling all hands to do the work of a watch encourages the idle to stay away, or to shirk when work is in progress. Each watch should have its strength developed by drill, and its organization perfected by careful stations and musters.

The station bills for working and sailing the ship adapt themselves readily to the watch bill. The force is always large enough for any rational evolution, and the superfluity of men to be drilled explains and justifies some combinations and exercises which might be found fantastic from a purely practical point of view.

The quarter bill or fighting organization must be regulated by more severe principles, while motive and manœuvring power must be maintained at the highest standard during action. Modern ships bristle with weapons requiring men to work them. Neither attack nor defense can afford to neglect any source of strength. Ships must be prepared to steam and manœuvre while large portions of their crews are on detached service. Finally, we must provide for a vigorous course of training which shall utilize and develop the fighting powers of every man in the ship. Men learn to sail a ship after a fashion, without special training, because they cannot help

taking part in the necessary work. They cannot, however, be trusted to pick up the art of fighting with great guns and small-arms, machine guns and torpedoes, without thorough organization and training.

Our present methods appear to recognize these necessities in principle. In practice they must be modified, to be thoroughly useful with modern armaments. Instead of forming a division of convenient size as a unit of organization for fighting and military training, we now distribute the material of the armament into groups and attach officers and men to guns, magazines or gear, according to arbitrary rules. The groups thus formed are called divisions, and form the basis of all subsequent organization and training. The idea of seniority is attached to these groups of material, and the removal of one officer breaks up all connection between those below him and the men for whose training they are responsible.

The gun divisions are generally fairly equal in force. The navigator's division varies greatly in size and efficiency. It may have five men or one hundred, but its commanding officer is rarely in a position to instruct it during drill hours, or to command it as a whole during action. The powder division is largely made up of inefficient men, who give a character to the whole organization and prevent the improvement of the rest. They are broken up in squads when stationed to pass ammunition, and usually receive only rudimentary instruction. They may do the work for which they are stationed, but they do it with much waste of numbers and strength, and in other respects make little progress towards military efficiency. The engineer's division is not drilled at all. Thus, only about one-half the ship's company receive a thorough course of training, or can do so under the present organization.

It is claimed that every man should belong to an efficient military organization, and should be trained for every kind of service according to his abilities. The great guns are only parts of the armament, and must not control the whole organization. The close connection between men and material is only important at the beginning of a cruise, and is not to be preferred to the connection between divisions and their commanding officers, which is now so often interrupted. To properly distribute work and responsibility, the divisions should be of uniform size and should be expected to receive equal amounts of training.

It is proposed to deduct from the ship's company the engineer's

force, marines, and first-class petty officers, and to distribute the remainder in divisions of forty to fifty men each, and of nearly identical composition. These divisions will be assigned to portions of the armament, keeping at least one division on the spar-deck for working ship. The powder division disappears, and each division has its own chain of ammunition passers. The navigator confines himself to his duties as ordnance officer and officer of the deck in action. The divisions are commanded by lieutenants, assisted by ensigns if possible. It should be the purpose of the detail of men to equalize the force, and to make the divisions complete working detachments. Progressive instruction should be given with a view to making the divisions interchangeable, but they should not be shifted unnecessarily. The connection between the lieutenant and his division should be permanent, as far as practicable. Messes should be arranged by divisions and watches, as far as practicable.

While all divisions should be instructed in the use of various weapons and prepared for detached service, it may be convenient in practice to class about one-fourth the men of each division as reserves to remain on board when more than two divisions are detached for other duty. This reserve would naturally be made up of coal-heavers, servants, rated men, and a few petty officers. The absence of men of these classes from daily drills may be tolerated at the discretion of the commanding officer. A record of all such absences should be kept and presented for inspection on occasion. The divisions should be paired to be combined under either of the lieutenants as a company of infantry, when the reserves are not landed, and when it is desirable to retain some of the regular division and watch officers on board ship.

The executive officer should have direct command of the whole force employed in working the armament. The navigator should work the ship under the personal direction of the captain. The navigator should have a fixed position in action, but the captain and executive should go where they can best direct the working of the ship and her armament. On no account should the three senior officers of the ship be grouped on the bridge or in the pilot house.

As a detail of organization, the use of telegraphs for working the helm and engines in action may be pointed out as highly important. A system of speaking-tubes to engine rooms, magazines, etc., is also required. Speed should be shown by revolution indicators, and the position of the rudder by a proper pointer, both under the eyes of the commanding officer and navigator. The terrible responsibilities of

command in action do not admit of the distractions of the old system of passing the word.

The practical conclusions drawn from the consideration of methods of organization are two in number:

1. Men must be stationed, worked, and drilled by watches in port, as well as at sea.

2. Divisions must be equal in force and each of them an efficient and complete military organization.

These propositions will be developed in succeeding portions of this essay.

III.—Seamanship and Sailing Drills.

In taking up the question of drill, we have to begin by considering what changes are necessary to sail most effectively our ships of latest type. As seamanship may be defined as the art of sailing ships effectively, we are called upon to draw up a programme for seamanship drills.

The object of seamanship in the mercantile marine is to make good passages. Men-of-war are subject to the additional requirements of keeping the sea in all weathers and sailing in company. Success in either class is measured by comparison of results rather than of methods, which must vary with the rig and propelling power of the ship—supposing the actual motive power to be regularly employed. The purposes and essentials of successful seamanship change slowly, while methods and details change with every improvement in motive power or steering gear.

Looking at seamanship as a practical art, we must study the parts which are undergoing change and adapt ourselves to new methods with the utmost promptness. We can study the practice of the past out of curiosity and to discover the tendencies of nautical progress. If we know what has become obsolete, we shall be ready to recognize what comes in its place.

The opposite view is held by a school which is lucky enough to have Mr. Ruskin as its literary advocate. He holds that seamanship went out when steam and iron came in, and that hemp and oak are the only materials which a seaman can use in learning his profession. A titled English admiral says that no officer can learn any seamanship on board an ironclad.

Reaction is supported in less picturesque but more familiar phrases

in our own service. Seamanship is held to be an exact and arbitrary science, like heraldry or etiquette. The permanent type of ships of war dates from the first half of this century, is ship-rigged, and carries studding sails. The loyal seaman is expected to steam under protest, and to insist upon large sail areas and manœuvring power under sail for all men-of-war. Obsolete ideals and fidelity to tradition are preferred to practical usefulness and professional improvement.

Seamanship drills are to be kept up as factors in the struggle against evolution, the protest against progress, which these crusaders maintain. The old-fashioned military delight in exactly uniform and simultaneous movements still lives in our cruising ships. Sending down royal yards is called a squadron evolution—though Paul Hoste and Darwin would be puzzled alike at such use of the word—and hundreds of men are called on deck to lower three little spars as the colors are hauled down. Those who call these things practical will hardly tolerate suggestions of change. They make a fetich of the mainsail and regard tacking ship as a sacrament, and care nothing for plans for drilling our ships to sail and fight effectively.

The genuine purposes of seamanship drills are two in number:

1. Development of the strength and activity of the ship's company, to promote health and discipline.

2. Preparation for service at sea, with special reference to probable emergencies.

The importance of the first of these purposes is just beginning to be insisted upon by those who fear the discontinuance of the old sail and spar drills. They are defended as gymnastic exercises conducted under the stimulus of competition. This view has its exponents among British naval officers who demand full ship rig as a nautical gymnasium, without much regard to the practical usefulness of the spars or sails in actual cruising. A mainyard 125 feet in length for an ironclad of low freeboard is an extreme case of the application of this doctrine. The actual and visible results of the present system of drills do not allow us to ignore their value as factors in the physical development of seamen. We must, however, seek to get the same results without waste of time, and to that end we must use more simple and direct methods.

If our methods of physical training are slow, wasteful, and indirect in developing the strength of the individuals of our working force, it is largely due to the practice of conducting all drills with all hands on deck, and leaving ordinary work at sea and in port to be carried

on in an unorganized and haphazard manner by watches or smaller detachments. We must correct this by selecting those portions of drills which afford muscular exercise, and applying them to watches or parts of the ship in such proportion that each man shall be called upon to exert his strength fairly and continuously enough to keep him in full training.

Our present system is also defective in preparing men for ordinary duties at sea, and for the most probable emergencies and accidents of a cruise. Exercises are not carried on with any direct purpose of effecting such preparation. Show, smartness, and *ensemble* are the qualities specially cultivated by our competitive drills. Speed is preferred to safety, and external appearance to sound workmanship. By working only for success in a competition in which time is the chief element, we encourage the use of flimsy devices, the "gilguys and gadgets" dear to the heart of the topman in a man-of-war. This introduces an element of danger, as demonstrated by too many fatal accidents at drill. A more serious danger lies in the habitual neglect of security and finish practically taught by such methods. Sails are insecurely bent and reefed and spars imperfectly secured aloft in order to make time; and seamen do not always remember to change their methods when working at sea, even in heavy weather. In port men are sent aloft before the gear is up, and are thus taught to evade the heavy work in a gale of wind at sea, as well as to expose themselves to danger while laying out on the yards.

The invariable practice of calling all hands for spar and sail drills destroys the likeness between exercise and actual work, and deprives seamen of opportunities for individual training aloft. In practice, ships are sailed by one watch at a time, and watch officers must learn to prepare for all probable contingencies with the actual force under their command. It is hardly creditable for a ship's company to have only one set of trained light yardmen during a whole cruise, but that seems to be accepted as a convenient solution of the problems of competitive drill.

Competitive drills with all hands also fail in providing for progressive instruction and continual improvement throughout the cruise. The first six months are occupied with zealous, if not altogether rational, efforts to approximate to the standard of the average cruiser, and success is marked by a cessation of interest and energy in exercising. Progressive instruction should correct this tendency, but it is not practicable to carry it on with a squadron made up of vessels

of various rigs and crews in different stages of training, except by assuming an equality which cannot be maintained in practice. We even go so far as to attempt to establish an arbitrary equality by rigging vessels with superfluous spars and sails which are useful only in ships of different power and tonnage. Happily, our new ships are to have rigs suited to their types, and uniformity has not been preferred to efficiency.

It is claimed that changes in drill are required to secure physical training, preparation for service, and progressive individual instruction. The present methods are not wanting in ingenuity or elaboration. They fail because they consider results as less important than traditions. Their purpose is too general and their routine too inflexible to ensure practical efficiency. They assume and attempt to enforce conditions of equality among ships which are neither true nor desirable for those of modern type. They make drill rather an end than a means of progress. They are based upon the theory that full-rigged ships are the only real men-of-war, and that reaction in that direction must accompany every improvement in steam machinery.

We must not make changes blindly, but must keep the objects of our system always in view. We must begin with rudimentary exercises and make our routine progressive. This implies the selection of simple operations for muscular training and discipline, and the assignment of men enough to perform them smartly and without opportunities for shirking. Exercises will require constant repetition at first to secure active and organized movement among masses of untrained men, and to promote individual instruction for those charged with special duties. Competition must be postponed until there is no necessity for the repetition of details. After details have been mastered and watches have been trained for their work at sea, combined exercises may be ordered and all hands worked together. These combined exercises should aim at substantial results of practical importance. They may be ordered for squadron exercises where ships are reasonably fitted to compete with each other. The comparison must be directed to results, and the simultaneous execution of detailed movements should be no part of the programme.

Competition should begin between watches, or among individuals and parts of the ship. Its premature application to fleet exercises will tend to cause hasty and inefficient work aloft and noise and confusion on deck. By concentrating the attention of officers during

the progress of an evolution, better work will be secured. Drilling by the motions is not necessary even for soldiers in actual service, and invites accident in men-of-war. A deliberate comparison of the completed work after each evolution will afford the best test of efficiency. Times should be noted, but only used as one element in comparing results. Thoroughness should be the first requisite, and quiet and orderly work should also be insisted upon.

But we must not linger too long in the prolixities of general discussion. Detailed and specific suggestions must be brought forward. Their presentation does not imply any intention of furnishing an absolute and invariable programme for ships of any class. The system must be flexible to ensure responsibility for results, and it must be experimental to encourage progress.

Let us take hoisting boats and bracing yards as elementary exercises important enough to be organized, and vigorous enough to be useful in developing the strength of the crew. The weight of boats being known, it should not be impossible to assign the proper force to hoist each or all of them. At any rate, a division by watches should be made and enforced whenever boats are hoisted. Squaring yards should never take all hands unless they are on deck for other purposes. As a rule, one watch should square yards while the other is cleaning ship in the morning watch. To make an exercise of it, the yards should first be braced up and then squared together. The men should be carefully stationed at the braces and the work done smartly. To complete preparations for steaming against a head-wind, the topsail yards might be mastheaded and braced up, and then lowered and squared with the rest. This is a suitable harbor exercise in all weather, and could be made spirited as well as useful, especially when a ship is first commissioned.

The work of loosing and furling sails in port should ordinarily be done by one watch. The other watch may be called on deck to man gear, but the working watch should frequently be sent aloft to prepare them for service at sea. They should also be stationed and drilled in setting all fore and aft sails together, and in hoisting topsails or setting other sails according to the force required. Shifting one topsail at a time is also a suitable watch drill, as it represents the only probable necessity of cruising under sail. Reefing comes last in the order of sail exercises for a watch. Still, it is often better not to call all hands to reef, and stations and drill should prepare the watches to do the work, as well as to shake out reefs in a smart and seamanlike manner.

Sending down light spars is also an operation for half rather than the whole of a ship's company. Sending them up together may require all hands, but it seems absurd to call on more than a quarter watch to work royal yards with the sails unbent. The advantages of having two or more sets of trained light yardmen are sufficiently evident.

None of these drills should be competitive between ships until they have been in commission for several months. Competition between watches and parts of the ship may be encouraged from the first. While the main object of these drills is to prepare watches for service at sea, it is evident that they would also provide the best preliminary training for more complicated exercises with all hands. In making combinations, we should keep in view the conditions and emergencies of practical navigation. No conventional or retrograde system should be established for the sake of uniformity or competition.

The system of watch drills should be kept up even after exercises with all hands have been attempted with success. It affords opportunities for repetition, and for successive and individual training. While the executive officer should superintend all drills, he should require the regular watch officers to carry on exercises with watches or parts of the ship. The morning watch could almost always be made to spare half an hour for one watch to drill in. Of course exercises should alternate, so as to train both watches.

Combined exercises or drills with all hands should be arranged for operations too heavy for a watch, and also with a view to competition between trained crews in ships of similar type. In such competitions a visible result should always terminate the evolution indicated by signal, and this result should have some practical meaning. For instance, a ship in port should be directed to prepare for getting under way, under either steam or sail, the signal indicating what spars were to be sent up or down. Four conventional rigs might thus be ordered by special signals.

1. Harbor rig for neatness and uniformity. Topgallant yards crossed; sails bent or unbent according to climate and convenience.

2. Sailing rig. Sails bent and gear rove off; boats up and booms alongside.

3. Steaming rig. Light spars on deck; yards ready for bracing sharp up; topsail yards mastheaded; covers on boats, etc.; fore and aft sail ready.

4. Fighting rig. Spars which might interfere with the battery

sent down and got ready for rafting ashore, or securing in booms; all gear likely to foul screws unrove or stopped in snugly.

The amount of work to be done by each ship should be settled as soon as she joins a squadron, and should depend upon her peculiarities of construction or equipment. Clearing ship for action should not degenerate into trivialities, such as sending down royal yards and unshipping hatch railings. The fact that a general clearance of superfluous spars and rigging must precede active war service at sea should be recognized.

For the purpose of keeping up activity and interest in seamanship exercises throughout the cruise, certain revivals of manœuvres may be tolerated. Crews may be exercised in shortening sail as though a flying moor were to be attempted. Tacking and wearing, box-hauling and chapelling ship, may occupy leisure hours, in light breezes, with some benefit to officers and crews. Still, these evolutions must not be allowed to usurp time and attention at the expense of more practical exercises. Captains do not care to sail into crowded harbors, or to beat through narrow channels. We have gained so much by the adoption of steam power that we ought to be resigned to the inevitable accompanying loss of sail power. Steamers of high manœuvring power under sail are not found among vessels of the latest types, and this essay is not intended to provide for their management.

While we are attempting to perfect the ideal training of our officers by putting full-powered steamers through obsolete evolutions under sail, little or nothing is done to give them experience in handling vessels in fighting condition—that is, under full steam power. The essential point of the seamanship of to-day lies just here. To avoid collisions on the high seas, officers of mail steamers, acting under the international rules of the road, are compelled to use the utmost vigilance, and to employ telegraphs, steam steering-gear, and every device of nautical science. To avoid rams and torpedoes, to attack an enemy or assist a friend, in the desperate *mêlée* of a modern naval action, will require still more dexterity and judgment. Can we leave our officers to pick up this essential knowledge, or shall we give them practical opportunities for acquiring it?

The palpable neglect of such opportunities in the naval service is due to a variety of reasons. In the first place, our manuals for study are without precepts, and our examinations for promotion are without questions calculated to develop a practical interest in the handling of

ships under steam. The standards of the past prefer sail to steam under all conditions, and treat steaming as a means of evading all nautical difficulties and responsibilities. Moreover, evolutions under steam require coal, and a certain opprobrium attaches to the expenditure of coal except in making passages where haste is ordered. We must learn to be practical in educating our officers, and to be liberal in ascertaining and developing the manœuvring power of our ships at full speed. Squadron evolutions will hardly serve our turn while they are regulated by a meaningless, rectangular system of tactics, and by the powers of the inevitable cripples, with leaky boilers and rattle-trap engines.

We must cultivate the manœuvring power of individual ships as a basis, or rather as a substitute, for all existing schemes of naval tactics. The first step should be to ascertain the actual tactical diameters and other data by experiment, and to familiarize officers with their meaning and use. This may not be what is understood by drill, but it is necessary to efficiency, and may serve as an introduction to other valuable exercises. Officers should be exercised in picking up moorings, in laying out targets, and in piloting the ship, to learn how to keep her under perfect control. Ramming rafts or other light obstructions, and dodging attacks by steam launches, are more specially warlike exercises which should follow in their turn. The problems of handling modern ships under steam are as varied as in the days of sail power. They require to be artificially repeated to give abundant practice for all the responsible sea officers of each ship. Time and coal must be allowed for such exercises, and as many of the officers and petty officers as possible must be employed in observing and noting results, as well as in working the helm and engines. The works of Captain Colomb will be of great assistance in elaborating details, as well as in demonstrating the necessity for such training.

While insisting upon the necessity for watch drills as required to train crews for actual service at sea, we should not ignore certain other advantages of the proposed methods. They should allow two or more operations, such as unmooring, taking in stores, hoisting boats, etc., to go on simultaneously. With a steam capstan it is wasteful to keep all hands standing by while a dozen men are heaving in a long scope of chain or picking up an anchor. Catting and fishing must of course be done by steam power, and a ship should be ready to get under way with a quarter watch. The rest of the ship's com-

pany might be hoisting boats, making sail or manning the guns. The military necessities of a vessel of war give additional importance to the training of detachments to do what is essential to get the ship under way and to navigate her.

Another disadvantage of the routine of drill is felt whenever a large liberty party is absent, or when firemen are cleaning or repairing the engines in port or working them at sea. It is also felt by the officers whenever drill hours and meal hours come too close together. In fact, useful exercises are often omitted from a dislike of mutilating the arrangements of the station bill, inaugurating an unfair competition, or interrupting preparations for meals. The training of the working force of the ship should not be sacrificed to such considerations. If servants and firemen must be drilled to aid in working ship, they should be exercised in manning gear, bracing yards, etc., at convenient hours. Without such preliminary work they are useless when called on deck with all hands, and actually interfere with the training of the seamen and ordinary seamen of the ship.

The solution of the ubiquitous servant problem may be found in a large reduction in the number allowed, to be compensated for by training in their special duties and by the introduction of modern improvements in lighting officers' quarters and in supplying water, etc. This, with a rational disposition of galley and pantry, hot-water supply, etc., and the detail of men to keep officers' quarters clean, will allow a large reduction without any sacrifice of comfort or convenience.

The use of modern domestic appliances should also facilitate cleaning ship, and thus leave time for regular and systematic exercises by watches during the morning or at other suitable hours. Watches should alternate in cleaning ship and exercising. At certain stations, in cold weather, scrubbing should be postponed until some hours after sunrise, and drill substituted during the hours before breakfast. Sanitary considerations are opposed to the indiscriminate use of water in cleaning lower decks, and the use of soft coal for distilling and similar purposes, in port, will discourage wetting even the spar deck unnecessarily, if apparent cleanliness is desired. The liberal use of fresh water, hot or cold, in cleaning decks and paint-work, is also a means of saving time. We might even borrow a hint from the domestic economy of our own homes and from the practice of foreign services in regard to scrubbing seamen's clothing. If tubs or tanks of hot

water for soaking soiled clothing, rubbed with soap over-night, were provided, it would be easy to save half an hour of the morning watch for purposes of instruction. Neatness would also be promoted, and wear and tear of clothing obviated. The use of steam dryers in large ships offers similar advantages.

The station bill, either for all hands or for one watch, should be used to muster men for exercises, so that they may acquire the habit of prompt attendance and may learn to find the gear. A period of fifteen minutes, before or after supper, would serve to prepare a watch or ship's company for a morning exercise.

Besides the general training given to the watches, we should provide for instructing smaller portions of the ship's company, parts of the ship, divisions, or boats' crews, in the performance of special duties. Fitting rigging, fishing spars, constructing jury rudders or sea anchors, are suitable operations to be performed on board ship by working parties under the charge of proper officers. Organized groups should always be assigned to such tasks.

Boats' crews should be employed in a variety of similar undertakings, running lines, carrying out anchors, etc. These exercises may be made competitive in a squadron with advantage. The use of boats as means for affording physical and nautical training should also be recognized and extended. The irregular requirements of service for landing and other duties will not suffice. Nor will the usual exercises in arming and equipping boats and manœuvring by signal serve our purpose. Boats must be called away for sailing or rowing exercise alone, and sent out in groups or pairs to instruct their crews. One officer can control two or more boats, and can learn as well as teach during the drill. The effect of sails, the use of the rudder, and the principles of old-fashioned seamanship, can be learned more rapidly in boats than elsewhere.

The same principles apply to the use of steam launches, which must form a larger part of the outfit of ships of modern type. Their usefulness in towing other boats is an essential feature which requires notice and development. The speed of a launch towing a string of boats should be accurately measured and recorded, with the time required to get up steam, and other data of military significance. The armament and instruction of boats' crews for various kinds of detached service will receive notice in succeeding pages. The present suggestions deal with the use of boats to supplement sail and spar drills in developing the strength of seamen and instructing them in the elements of seamanship.

Individual instruction in seamanship must largely be left to the operation of natural causes. We assume a certain amount of training and assign duties in navigating the ship accordingly. Men learn by daily experience and by association with petty officers. We are not called upon to make radical and elaborate suggestions and rules for teaching everything connected with this subject. Ships are sailed continually, but fought very seldom. We must therefore concentrate our attention upon the methods required to make men comprehend naval warfare and to prepare them for action.

The improvement of individual seamen can be provided for by offering higher ratings to those who are qualified. The limits of the complement should not prevent such advancements, at least during the latter part of the cruise. There is some absurdity in discharging men of good physique and intelligence as landsmen or ordinary seamen after three years' service in a man-of-war. Here, as elsewhere, we must rely upon the setting up of standards for encouraging and securing progress. Let the qualifications of each rating be definitely stated and permission given for all men of approved character to present themselves for examination. One year's service before advancement and one year's interval after failure should be required from recruits or other candidates. Liberality in this direction will encourage useful and practical self-education.

In bringing this lengthy and discursive chapter to a close no attempt will be made to summarize all its conclusions. The principle insisted upon is that drills should be established with a practical purpose in view, and that the object must never be sacrificed to conventional or traditional standards. Of the two objects put forward here —physical culture and preparation for service—the first admits of some latitude in the selection of methods by which it may be secured. While practical views must be accepted, we need not be too severe in applying them to exercises which have the advantages of being familiar and showy in the eyes of old men-of-war's-men. We may continue to tack and wear, loose and furl sails, and send down top-gallant-masts with all hands, if we remember the prime necessities of giving each man his share of a day's work and preparing the watches to do their duty at sea. If these essentials are neglected, no exactness in the swaying of yards together can make the ship efficient. The necessity for drilling squadrons by the motions is not apparent to the writer, who is even prepared to assert that there is no sense in combining the ceremonial of colors with practical exercises in seamanship.

In spite of such a degree of radicalism, it is impossible to leave the consideration of this section of our subject without expressing some toleration for the old drills which we may find means of retaining, and some regrets for those which must be rejected as obsolete. When methods of fighting are taken up in turn, we must, however, waive all sentimental sympathies and be severely practical and progressive.

IV.—Armament and Preparation for Battle.

Preparation for battle must be the watchword of all systems of organization and instruction for men-of-war. Armament and training must be alike rational and progressive. Nor will it answer to postpone this preparation until war is at hand. This would make our naval battles mere experiments, offering us solutions of professional problems at the expense of our ships. The study of all the experiments and failures made by foreign powers becomes a question of safety as well as efficiency to our service. The work of noting the facts may be left to the Office of Naval Intelligence, as now happily organized, but the observed results must be analyzed and published for the use of all officers, if our ships are to be prepared for actual warfare.

We need not, however, wait any longer for information to accumulate proof of the necessity of radical changes in our methods of attack and defense. It is not even necessary to look outside the armament of ships now in commission to realize the failure of our present system of drill in developing and utilizing the powers of modern weapons. The introduction of new weapons will only serve to make this failure more conspicuous.

At present the battery of great guns is treated as representing the fighting power of the ship under all conditions. In ships with rams this method of attack is practically ignored. Spars are permanently fitted to interfere with its use; and the officers are not assisted by telegraphs or trained by full-speed trials to manœuvre their ships in action. Spar torpedoes exploded by electricity are fitted to ships, but no precepts are laid down to regulate their use in action. It has been held that even large and slow ships might surprise an enemy at anchor and attack with this weapon. It is now hinted that ramming attacks may be averted by employing it. The first view requires no discussion. For the second suggestion there is the fact that ships

cannot surrender any part of their speed or turning power to employ such an uncertain weapon as the spar torpedo. Even at anchor the spar torpedo is inferior to a group of mines.

The only methods of attack and defense for which our Ordnance Instructions provide in detail are those by boarding. The principal use of machine guns is said to be "to prepare and clear the way for the boarders." Small-arm fire is reserved for the same improbable occasions. Riflemen and marines are rarely called on deck at general quarters, except to support or repel boarders. In the latter case they may be supported by a heterogeneous mass of men armed with all kinds of archaic instruments of warfare. Every general inspection sees crowds of men wildly rallying and charging about on uncovered decks in imaginary action. Can we suppose that our seamen can be made to take such drills seriously when in port with foreign ships whose tops and bulwarks bristle with Hotchkiss guns?

Nothing is done to develop the powers of these weapons to keep down the artillery fire of an enemy or to interfere with the command and steering of his vessels in action. Nor are commanding officers directed to organize or instruct their small-arm men or machine guns' crews to repel torpedo boats. If this means of defense is neglected, it will be idle to expect any amount of "ingenuity" to keep our ships afloat in war-time. In fact, the whole scheme of attack and defense may be set down as antiquated and inefficient.

This criticism does not involve any reflection upon those who administer our present system. Most of these defects are due to tradition or to the survival of obsolete material. Our system of drills is only a little behind our armaments. Our armaments are quite as good in their kind as our ships. The ships themselves are no worse than they should be, considering their age and the methods of administration under which they have been designed, constructed, and repaired.

Considering the armament of our ships of latest type as the basis of the proposed drill programme, we have, in the first place, high-powered, breech-loading rifled cannon to replace the smooth-bores so long retained. It is evident that this change must seriously modify the methods of aiming and firing, unless all the advantages of rifled guns are to be sacrificed. Auxiliary batteries of Hotchkiss revolving cannon are promised for the new cruisers, and rapid-firing shell guns will also be required to complete the armament, if the ships are to be fought effectively. Magazine rifles of approved pattern will also be recognized and supplied as essential to the power of the ship

in action and to her defense against torpedoes. They should be accepted as the standard weapon for all landing parties and all boats' crews on detached service. Enough rifles should be put on board to arm at least 80 per cent. of the ship's company.

Among the weapons displaced by modern armaments, we find all smooth-bore guns, from the XV.-inch Dahlgren to the 12-pounder bronze howitzer. The 3-inch rifle—so long the sole specimen of modern ordnance in our collection—will find it hard to keep its place against the intrusion of Hotchkiss rapid-firing guns of high power. The want of a proper rail-mounting has made this gun almost useless up to the present time. As machine guns and magazine rifles have put boarding out of the question, we must anticipate the disappearance of swords and pistols, pikes and battle-axes, as special naval weapons. If cold steel is to be retained at all, it should be in the form of bayonets for magazine rifles. At present, the obsolete cutlass and the impracticable revolver usurp about as much of the time of our officers and men as we devote to the accurate and invaluable magazine rifle.

If we are to differ from foreign navies in dispensing with the automobile torpedoes, we must resign ourselves to making the best of the spar or out-rigger torpedo. This may involve its disuse as a portion of the fighting outfit of our ships, and its practical development as a weapon for steam launches of all types. It is to be hoped that at least one genuine torpedo boat may form part of the equipment of each of our new cruisers. Mines or stationary torpedoes, for use in defending vessels at anchor, may also be supplied. Whatever torpedo armaments may be adopted must have men to work them. The necessity for relief crews in torpedo boats will compel us to train a considerable portion of the ship's company in handling explosives, working torpedo spars, and laying out mines. Every line officer should share in this practical instruction while on sea service. No advanced course in electricity and chemisty is required to prepare officers and men for practical training in the elements of torpedo warfare.

The plan of organization heretofore discussed distributes the complement of all ships into equal and interchangeable divisions of 40 to 50 men each. It remains to develop and apply this scheme to the immediate preparation of the armament for service, and for the progressive military instruction of the crews of our ships of latest type.

As an illustration, let us take the Atlanta as a ship to be organized

according to the plan suggested. Accepting the estimate of 230 men as her complement, on the supposition that she cannot berth a larger number, we have to adjust this force to the armament proposed. In round numbers, we can set off 50 men, including first-class petty officers, a strong engineer's force, and a small marine guard, as already assigned for duty in action. This leaves 180 men, to make up four divisions of 45 men each. Four lieutenants, junior to the navigator, should command these divisions, with junior line officers as assistants. The natural assignment of divisions would put three of them in the superstructure to work the battery, and leave the fourth division to work rapid-firing guns on the upper deck and in the tops, to assist in navigating the ship, and to serve as small-arm men under the direction of their proper officers.

In stationing men at the guns, two reliefs should be assigned to guns having bow and stern fire, to all Hotchkiss guns, and the guns in one broadside. If the mechanical carriages are properly designed and constructed, five men should be able to work each 6-inch gun effectively. For 8-inch guns seven men may be allowed, and for Hotchkiss guns three each. These numbers are intended to admit of the regular relief of crews at short intervals. In French ships five men work 24-centimetre guns, mounted on turn-tables, with great ease and rapidity, and our men should be able to do as well. Men not stationed at the guns should keep up the supply of ammunition.

In detail the allowance for gun divisions would be as follows:

1st and 3d (Forward and After) Divisions.

1st Relief (8-inch B. L. R., 7 men; 6-inch B. L. R., 5 men; 2 Hotchkiss, 3 men each),	18
2d Relief,	18
Ammunition passers,	9
Total,	45

2d (Amidships) Division.

1st Relief (2 6-inch B. L. R., 5 men each; 2 Hotchkiss, 3 men each),	16
2d Relief,	16
Ammunition passers,	13
Total,	45

The advantages of this system will hardly be questioned by those who are willing to admit its practicability. In taking up drills in detail, an effort will be made to deal with all apparent difficulties in its application. In general it will be the duty of the division officer to work his force as a whole, and to employ both reliefs in casting loose and providing the guns, and in removing obstructions and repairing damages during action.

The supply of ammunition by the men of the division may seem to require some explanation. It should be quite as practicable to connect the control of the ammunition passers with the guns which they supply, as it is to maintain the present scattered and loosely organized system. The officer of the powder division of our ships must be ubiquitous, to regulate the working of all the groups and chains of men now stationed to handle ammunition. These chains diverge from his control, while the proposed groups would lead directly from the magazine or shell room to the guns under the direction of the officers working the battery.

It is evident that the present system of supplying powder is a mere survival from the days when ships had several decks and a large number of guns on each. Its elaborate arrangement of chains and scuttles assumes this, and supposes a great variety of guns of similar calibre in the battery. The fact that the handling of projectiles receives such scant attention, indicates the antiquated and unpractical nature of present methods. The real source of delay when firing is going on is in the whipping up of heavy projectiles from the shell rooms. This is largely due to bad stowage and awkward arrangements, which require more care for their correction than is needed to prevent any possibility of mistake in regard to the destination of charges of powder.

Of course, the construction and arrangement of store-rooms for ammunition should assist organization in facilitating rapid and regular supply. In a recent British ironclad each gun has its own magazine and shell room, with a common hatch or elevator for delivering its supply of ammunition. Detached guns of 6-inch calibre were among those thus provided. Without going so far as this in cruising ships, we should try to make progress in this direction. For heavy modern guns this arrangement is the only one that is practicable, and our organization should anticipate the development of our artillery and water-tight compartments with doors closed during action. The stowage and handling of shells might be facilitated by dispensing

with boxes, and strapping the shells so that they should be slung by the point for hoisting and carrying. A block might be fitted over the point to protect the fuse, and a becket attached to metal straps passing under the base. Whipping up long shell in boxes slung in the middle is inconvenient in an ordinary hatchway.

Speaking-tubes should be fitted to allow the executive officer to give preliminary orders to the gunner or gunner's mate in charge in the magazine or shell room, and also to enable officers in charge of gun divisions to call for ammunition. This would be better than relying upon the polyglot contingent at intermediate stations to pass the word, or upon the necessarily intermittent control of the officer of the powder division. Other expedients will be suggested when detailed exercises are under discussion.

The purpose of the proposed organization as adjusted to the battery of the Atlanta is to provide for the immediate readiness of the armament of the ship upon going into commission, as well as for the progressive individual instruction of the members of the crew according to their various capacities. The distribution of the complement of any ship could be regulated by the same principles. A large ship might have two divisions to do the work now done by the navigator's division, and to keep up the fire of light guns and small-arms during action. Moreover, all the relief crews not actually working the guns would always be available as riflemen, firemen, or wreck-clearers. They should be equipped as riflemen whenever the guns are cast loose in action, and rifles and belts for all the men in gun divisions should be distributed in racks ready for use. The relief crews might be sent below for shelter or for rest or refreshment, according to circumstances. The men actually working the guns should not be required to wear accoutrements, or to answer calls individually, though they may be detached in a body to act as riflemen.

Taking up the actual service requirements in their order, we have to arrange a system of exercises for securing two principal objects:

1. The immediate preparation of the whole armament for efficient service in action.

2. The training of all divisions for the performance of various kinds of detached service in time of war.

As we cannot hope for perfect success in either direction in the limits of a three-years' cruise, we must establish a continuous and progressive system of drill and instruction, to accomplish as much as

possible of the desired result. It will not be practicable to sacrifice one of these objects to the other, either in point of time or otherwise. The defense of a ship often requires the detachment of part of her force, as well as the development of the full power of all the weapons which she carries.

We must now attack details and seek out the modifications by which our present mechanical drills can be transformed into a rational and progressive system of individual instruction. The phrase used in making entries in the log is too accurately descriptive; divisions are "drilled according to routine," which means that officers feel very little responsibility and men take very little interest. The suggestion has been made that officers can be made responsible only by allowing them a certain amount of liberty in regard to methods, and requiring the attainment of definite results. This will involve greater permanence in the connection between the divisions and their commanding officers. No general fleeting up or arbitrary scale of precedence should interrupt systematic training.

As a means of encouraging progress, men should be classed according to drill and training, in order to furnish a standard for measuring results and apportioning responsibility. Three classes might be established, as follows: 1st Class.—Trained men: fit to serve as gun captains, file-closers, and coxswains of armed boats. Marksmanship is a prime requisite for admission to this class. To be examined by a board on presentation of names and record of target practice by officer of division. 2d Class.—General-service men: familiar with stations, at guns, infantry drill, and rifle practice. They should be good oarsmen and expert in care of arms and cleaning brightwork. A certain percentage at target practice is essential—say 40 per cent. at 200 yards. 3d Class.—Men who can march with a company, pull in a boat, and fill a station at quarters. Men should be assigned to the second and third classes by the commanding officers of their divisions. Recruits and others should not be classed until they have received a certain amount of instruction. Rating and length of service should not affect this classification. Officers should be encouraged to bring their men forward for the higher classes, and the number in each class, as well as their average proficiency, should be carefully noted at each general inspection. The classification and the marks upon which it is based, including a final average of target practice, should be noted upon each man's discharge or continuous-service certificate.

Any thorough course of progressive instruction must require more time than is allotted to the present routine drills. In port or at sea, in pleasant weather, it will be easy to find unoccupied hours enough during the forenoon to admit of two hours' drill for the body of the crew. An occasional afternoon hour might also be utilized.

All this will impose extra work on those officers whose regular duties involve more exposure and fatigue than those of any other class on board—viz.: the lieutenants who stand watch and command divisions. At sea they have real and responsible duties to perform. In port their presence on deck at all hours and under all conditions is a concession to routine and tradition rather than to any practical necessity. There are plenty of junior officers in the service who are without any regular and responsible duties. They could acquire the habits of command by standing watch in port without risk of impairing the discipline and efficiency of their ships. The simplest solution of the question would be the requirement that all commissioned officers of the line should take charge of the deck in port. The executive and navigator are, of course, excepted, and officers temporarily engaged in other work, such as compiling local information, surveying, or special ordnance or torpedo duties, should also be excused. This would improve the unfortunate position of ensigns, and it would allow lieutenants to give more time and attention to the instruction of their divisions. At sea no change is essential in the distribution of responsibility among officers, though junior officers should have a chance to acquire a practical knowledge of their profession.

It is proposed to establish a system of exercises which will leave no opportunity for wasting the two or three hours off watch which the average lieutenant would gain by putting ensigns on duty. Besides the extra time required for practical exercises, there will be occasion for increased study in preparing progressive courses of instruction. A certain amount of clerical labor is also required from officers in charge of divisions.

Ships with a reduced complement of officers must distribute the responsibility by day's duty. Three watches cannot be carried on in port, with any strictness, without depriving officers of the spirit and energy necessary to secure the thorough training of the men under their command. Works on military hygiene recommend that guard duty should be arranged to give soldiers four nights out of five in bed. Naval officers cannot expect so much consideration, but the

facts of hygiene can hardly be ignored without loss of efficiency. The preceding suggestions are not, however, based on such grounds. They are made with a view to professional improvement among the officers and practical efficiency for ships' companies.

I am tempted to add, as a mere personal expression of opinion, that I see no harm in allowing the officer of the deck, in a well-disciplined and securely anchored ship, to stand part of his night watches in a conveniently situated chart room or pilot house on the upper deck. While there, he might occupy himself with professional study or work in connection with his duties as a division officer. Concessions of this kind, if properly regulated and recognized, would do more to secure vigilance and intelligence in the performance of duty than the mechanical routine of walking the watch realizes in practice. This suggestion is commended to the use of the naval authorities of Utopia, as I am aware that it will not be received with favor by those who control American ships of war of any type.

The details of a drill system we may well begin with the great guns. The introduction of mechanical and automatic carriages should promote accuracy and rapidity of fire and simplify drill by reducing the number of men stationed to work the guns. These changes tend to render great-gun drills less suited to competition,—less active, and, therefore, less useful as a muscular exercise. The guns can no longer be sent crashing into the water-ways in running out, as in the old days of four-truck carriages, with their tackles and handspikes. We must rely upon mechanism to work high-powered guns, and crews must be made familiar with its details and taught to keep it in perfect order.

To ensure the proper condition of the battery, the usual morning inspection at quarters should always include an examination of the guns and their carriages. After mustering the men and inspecting their clothing, the guns should be cast loose, run out, trained, run in, and secured by the proper orders, with strict attention to details, as well as to the condition of the gearing, hydraulic cylinders, and brightwork. The breech should also be opened and the bore of the gun examined. This will prevent the rusting and sticking of parts which sometimes occur. While one relief is working the guns, the other should be inspected as riflemen, and the ammunition passers should be put through their stations. Both reliefs would be required to work the broadside guns. At other divisions, they should alternate as guns' crews and riflemen. Fifteen minutes should be allowed for muster and inspection, which should be thorough and practical,

and conducted as a strict military formation. This exercise should serve to keep the crews as well as the guns in good working order, and should take the place of longer great-gun drills, which are apt to become very tedious with mechanical carriages.

The only real test for efficiency of armament in a man-of-war is the rapidity and accuracy of fire. The most important drill must be that which most directly secures progress in that direction. In practice, delays in firing are more often due to the imperfect training of gun captains than to any other cause. Misses and wild shooting are due to the same deficiency. The supply of ammunition and the loading and training are all minor difficulties. Quick and accurate sighting has not yet been mastered by any considerable proportion of our continuous-service men. This must be attributed to want of systematic instruction and practice. The object of quarterly target practice seems to be the transmission of reports to the Bureau of Ordnance. Certainly it is not the custom to publish the records or diagrams for the information and encouragement of divisions. Hardly any appeal to the intelligence of men is made to avoid waste of ammunition, and the simple methods of comparison of records, by which earnest competition might be inaugurated between ships or between divisions, are altogether ignored. Our failure to utilize the results of target practice is accompanied by neglect of the training necessary to prepare for target practice.

The recognition of aiming drill as a necessity in preparing for effective fighting, must involve the assignment of regular periods for the instruction of all men capable of improvement. Advanced training for the best men, and elementary instruction for all, will require the attention of division officers during the whole cruise. Instruction in aiming should be the regular exercise with great guns and all rapid-firing guns. The crews will be made familiar with the mechanism of the carriages and slides by the regular morning inspection of the battery. Loading may be taught incidentally during the drill, using dummy cartridges and projectiles, and the necessary information in regard to ammunition, stations, etc., may be given to the more ignorant portion of the crew while aiming drill is in progress. The latter should be taught by the officer of the division who will be called upon to regulate firing in action. Rudimentary instruction should be given by junior officers, assisted by qualified petty officers.

The details of instruction should be practical and varied enough to be always interesting. This will involve an active interest on the part

of division officers, and some extra work in measuring distances from the chart to be used in teaching the men how to estimate distance and use their sights. By keeping records of the progress of each man, by connecting the training in pointing with actual practice through inspection of targets and explanation of diagrams, and by using competitive exercises to incite progress, results of the highest value may be attained. Times required for sighting should be noted; men should be called up to verify the point of aim for which a gun has been laid by a gun captain; rapid-firing guns should be made to follow a moving object, using the open sights. Valuable suggestions will be found in the "Handbook of the Hotchkiss Rapid-Firing Gun," by Lieutenant E. W. Very. The methods of the Army Manual of Rifle Practice may also be adapted to naval uses with guns of all calibres. Aiming drill should occupy about half an hour two or three times each week.

Considering rifle fire as a means of supporting the fire of the battery and keeping down an enemy's fire or interfering with his steering in action, the necessity for careful training in aiming and firing will be manifest to all. Without such training with small-arms, no ship is fit for active service, or even to defend herself against attack by torpedo boats. Aiming drill with rifles should lead up to similar exercise with great guns, as well as to target practice. Aiming should be taught by the latest and most approved manuals, and should occupy about the same time each week as the corresponding exercise with great guns. This claim does not arise from any purpose of turning sailors into soldiers. This is not yet under discussion; but it must be admitted that marksmanship is required to fight a ship effectively just as much as seamanship is for efficient navigation. Rifle practice must be taught for use on board ships, in tops or boats, and riflemen must learn to distribute themselves properly, to concentrate their fire, to fire volleys at the word, and to take advantage of the bulwarks for cover and for resting their pieces in firing.

Aiming drill must be followed by target practice, which is, perhaps, the most practical of all military exercises. Drill generally consists in going through the motions without accomplishing anything. Target practice gives an actual result and furnishes an absolute standard for measuring efficiency. It must be taken seriously and made as thorough and practicable as possible.

Among the drawbacks which make naval target practice ineffective in securing marksmanship, a few require mention. Men are sent out

for practice before they have received any aiming drill or fired any blank cartridge. They fire over too long ranges or at small targets which they are unable to hit, or at floating or swinging targets for which it is impossible to keep scores. If a man fires five or ten rounds without seeing where his shots strike or learning to correct his aim, he has wasted his ammunition. If he makes a clean score of misses without finding out why he fails to hit, his chances of becoming a marksman and his value as a man-of-war's-man have been injured instead of improved.

Remedies will suggest themselves to any one who realizes the importance of the subject. Preliminary aiming drill is indispensable. Ranges and targets must be adapted to the circumstances and the qualifications of the men firing. Scoring must be thorough, and the result of each shot should be signalled. Markers must be trained and scores must be shown to the men. Finally, the officer in charge of the firing must be required to give his best attention to the firing of each man. This may involve a reduction in the number of men taken on shore, and it will certainly require a police force for all ranges outside of navy yards. Seamen cannot be expected to shoot well with their worst enemy—liquor—taking them in rear. A detail of a corporal's guard of marines would often enable an officer to improve the shooting of his division 50 per cent.

For naval uses, canvas targets should be supplied, to be laced to uprights of iron plates or light angle irons with wire guys to support them. Squares of old canvas would answer, with ready-marked facings of paper to be pasted on, or muslin to be stitched on, to renew them. No difficulty would be found in transporting such targets, and no time would be lost in setting them up, if markers are properly instructed before they leave the ship. Miniature targets for use with parlor rifles are also indispensable for use on board ship.

As a means of securing permanent benefits from target practice, complete records should be kept and brought forward on all occasions to interest the men and incite them to improvement. Competition between different organizations should also be encouraged by comparing averages and results of volley-firing. The individual scores may be made most useful by furnishing each man with a small score-book, wherein each shot that he fires, either with rifle, machine gun, or great gun, should be entered, and the score certified by his division officer. The production of these scores should be made a feature of general inspections, and their significance should be constantly impressed upon the men during instruction.

The same books should have pages and forms for keeping clothing lists, making requisitions, etc. They should be used and verified whenever clothing is overhauled and inspected. All entries should remain in pencil until after verification by responsible officers. Nearly all of our men can write, and they should be encouraged to make so much use of their education as would be involved in making these entries. The same note-books might contain a few pages of instructions in regard to gunnery, stations, and other particularly useful information. They should be small and well bound in soft leather. They would improve marksmanship enough to pay for their cost in a single quarter, if we count all ammunition wasted which does not result in hits, as we should always teach seamen to regard it.

Combined target practice at sea must also have its standards and methods of scoring. The targets should be large enough to catch all shots properly aimed from rapid-firing guns and small-arms. Diagrams for plotting great-gun practice should be used in the same connection, and all results and records exhibited and explained to the men engaged in firing. Lieutenant Very says, in the manual previously mentioned: "As much is to be learned by studying the targets made as by the actual shooting."

It may be necessary to use arbitrary and approximate methods in recording great-gun practice at sea; but some methods of comparison are essential if men are to derive encouragement and improvement from the costly experiment. It will frequently be found possible to fire at rocks of known dimensions with targets marked upon them where practicable. Large screen targets can be constructed of boards and placed on reefs or sand-spits, or on piles driven in shallow water. For squadron exercises such targets should always be constructed. A very small percentage of the cost of the ammunition wasted in wild or unrecorded firing would pay for targets that would make these exercises practically significant and permanently instructive.

For sea or floating targets there should be a raft supporting a canvas target with its base an equilateral triangle and its three vertical sides six feet high by twelve feet long. For combined practice it should be marked by a black belt one foot in width, and vertical stripes at the corners and in the middle of the sides. For experimental practice with rapid-firing and machine guns, it might be painted a neutral color, to represent a torpedo boat. The actual work of framing, rigging, and mooring such a target would form a useful seamanship exercise for junior officers and boats' crews. Such

targets would be adapted to practice while drifting in a tideway, and should be capable of standing upright in a moderate seaway.

No one who has noted the effect of a spirited and successful target practice on the crews and divisions which have made good shooting will be disposed to allow such interest to evaporate. Smartness in drill, attention to instruction, and promptness in cleaning brightwork are among the direct and visible results of success in competitive firing. If these are worth cultivating, we must have better targets, and a thorough and intelligible record of practice.

The expression "combined target practice" has been used to indicate the use of the various component parts of the battery to render mutual support. This enables the Hotchkiss guns, with their explosive projectiles, to be used as range-finders, to regulate the fire of the great guns. Volley-firing with rifles and rapid fire with Gatlings may serve the same purpose at short ranges or in smooth water. The regulation of fire from all these weapons must be studied and made the subject of experiment and exercise, to avoid danger and failure in action. Small-arm practice on shore must precede the general exercise of the crew in firing at floating targets, but selected marksmen should always be posted to keep up a well-directed fire in action.

The feature of highest value in combined firing is its likeness to actual fighting. This resemblance should be emphasized and made as real as possible. The same idea should dominate all exercises at general quarters. The nature of the imaginary attack and the force, bearing, and distance of the supposed enemy should be communicated to officers of divisions, and guns should be loaded and laid in anticipation of his movements. General quarters should have the same relation to aiming drill that combined target practice has to divisional rifle-firing.

It may be objected that too much time is required to admit of systematic target practice, either for rifles or great guns. This can hardly be the case while steamers are sent to sea to cruise for a week or more, with light breezes, in summer. The difficulty seems to lie in some distorted comprehension of the relative importance of different exercises. Opportunities for drills and exercises of vital interest are passed by because a slight interruption of the prescribed squadron routine would be involved. Ships must be allowed time and coal for careful and rational target practice with their batteries. They must not be allowed to fire away

their allowance in desultory or perfunctory practice, when there are hundreds of outlying rocks which might serve to give sound training to their gun captains and furnish data for the solution of vexed questions in modern naval artillery. If ranges on shore can be found within the limits of a station, ships must be sent there at least once a year to complete a certain amount of target practice—say 50 rounds per man. If time is limited, other exercises must be suspended and routine must be modified or temporarily sacrificed to more practical requirements.

Similar considerations will certainly impair the standing of such exercises as single-sticks and pistol drill as essential parts of the routine of a ship carrying magazine rifles and rapid-firing guns. We must choose our part, and we must yield to the tendencies of our age. These weapons are obsolete for general use, and exercises with them are abortive and fantastic. It may be said that broadsword fencing is a good exercise for the muscles and develops a fighting spirit among the men. If this were true, it would deserve as much recognition as we now give to boxing, and no more. But practical experience convinces me that our routine single-stick exercises develop no interest or instinct whatever among seamen. Ten years' drill does not secure any actual progress. For the revolver, it is sufficient to say that "it does not develop in practice the advantages claimed for that kind of arm." For once we can agree with the Ordnance Instructions of our youth.

Those drills which have been rejected here will hardly reappear when we come to consider methods of preparation for detached service. Substitutes for them will be suggested, and it is thought that all the advantages claimed for them may be attained without consuming the time and energy of instructors and ships' companies in exercises which have no direct practical value or significance.

The special duties of those divisions which are not stationed at the guns are evidently the same as those now assigned to the navigator's division. Their instruction should be revised and advanced far enough to recognize the existence of the screw propeller, water-tight compartments, and other modern improvements. Leaving all repairs of spars and rigging to be executed at leisure, and giving up their futile stoppers and fishes, they must keep the screw clear, look out for the steering gear, and remove obstructions to the working of the guns. To clear the screw a special grapnel guided by a pole and worked by whips to the gaff and yardarms should be fitted. The

use of sails and mats for stopping leaks must also be made a regular exercise. Water-tight doors must be worked by the engineer's division and ammunition passers on lower decks.

This last class must be carefully stationed and drilled. To prevent confusion, projectiles and charges may be checked by attaching metal tags showing the division for which they are destined, and the weight of the shell or powder sent up. These checks should be used at all general exercises without ammunition, and should be rigorously accounted for when firing takes place. Any blundering or tampering with the checks should be punished severely. This expedient will, it is thought, secure better results than are attained by the present straggling arrangement of the powder division.

V.—Training Men for Detached Service.

The requirements of detached service have been touched upon in treating of complement and organization. It has been claimed that a ship should carry men enough to land an effective force without sacrificing her powers of defense or navigation. The organization of equal and interchangeable divisions has had this purpose in view. The distribution of trained men of all classes, from carpenters to cooks, is necessary for the complete efficiency of detachments. There should be a quartermaster or signalman in each landing company or group of boats, as well as officers' servants and berth-deck cooks to look out for messes. The assignment to regular messes should be by divisions, with the exception of petty officers and servants, who may be otherwise provided for. Boats' crews should be assigned on the same basis, and boats should be grouped under the control of divisional commanders.

Instruction should be adapted to organization, and should go as far as possible with each man. The untrained and ineffective forces which now make up the bulk of the powder division may hardly be advanced beyond elementary rifle practice, which should also be the only military training required from the engineer's force. For the remaining portion of the crew progressive training must be the rule; differentiating according to individual capacities.

The principal weapons with which men must be trained for detached service on shore or in boats are, in the order of importance and frequency of use, as follows:

1.—Magazine rifles. Taking the Spencer-Lee as the accepted

type, each man should carry 60 to 80 rounds in the loops, and four filled, detachable magazines in light pockets inside his woven cartridge belt in front. Reduced amounts may be carried for practice or special service. Reserve ammunition in boxes strapped for slinging and carrying may also be supplied. Light bayonets may be carried in leather buckets like the sling cases of a telescope, to be served out and fixed on landing or boarding.

2.—Light, rifle-calibre machine guns or single-barrel, rapid-firing shell guns. The former have some advantages for use on shore, but their continuous fire gives poor results in boats. Light field carriages capable of quick train should be fitted to carry a liberal supply of ammunition.

3.—Light or heavy rifled howitzers for special services, such as attacking an enemy sheltered by brick or stone walls or houses or intrenched among rocks. These, and their obsolete companion the smooth-bore bronze howitzer, appear to be considered as the special arm of seamen on shore. They are massed in battalions and trundled through the streets of our cities on all ceremonial occasions, in spite of their awkwardness and ineffectiveness for display or service in the field.

The persistent favor shown to these last-named weapons compels an inquiry into their real value. In the first place, they are almost useless against troops in extended order or under natural cover or that furnished by earthworks. Neither the attack nor the defense of Plevna was able to employ artillery with effect. In the next place, the development of rifle fire exposes the gun detachments to many dangers, due in part to their slowness of movement and the massing of men at the drag-ropes. The range of small-arms is quite equal to that of most naval howitzers, and the accuracy much greater. The scanty supply of ammunition is also a source of weakness. The employment of perpendicular or high-angle fire would seem to give machine guns and small-arms such a decided advantage over howitzers as to involve their withdrawal from all field movements. Two facts noted with reference to European field artillery tactics support this view. All field movements in action are supposed to be conducted with the horses at a gallop from the instant of limbering up, and guns are not to be brought into action without infantry supports deployed at least 600 yards in advance.

These considerations seem to forbid the subordination of all landing organization to the awkward necessities of field artillery without

horses or limbers. When landed for battering houses or walls, howitzers should be worked by one relief, supported by the remainder of the division. Bayonets should not be carried by the men at the drag, and their load of rifle ammunition should be reduced. The same arrangements should be made for working such machine guns as may be landed. Higher numbers may carry revolvers at the guns instead of rifles. Being trained men, these numbers will readily learn to load and fire revolvers without making that one of the routine divisional drills.

Accuracy of fire with all these weapons is essential to the preparation of ships for naval actions, and a system of aiming drill and target practice has been elaborated with that end in view. Few changes will be necessary to make the same methods apply to service on shore. Firing from a rest must be encouraged in boats and on board ship, but men must not be allowed to depend upon finding rests while on shore. Judging distance must be taught under various circumstances at every opportunity, especially while on shore.

While complete divisions may be landed for drill and firing or detached for special service, it may be best to combine them in pairs for the permanent battalion organization for parades and distant service. A company of 72 men, with three officers, would be formed by leaving out the reserve men or ammunition passers from each division and alternate division commanders. These men should serve as boatkeepers and shipkeepers in port, and, with the assistance of a complete division, should suffice for the safe navigation of the ship and her defense against attacks by an inferior force. This disturbance of the relation between an officer and his division is suggested with reluctance as a means of detaching a full fighting force without crippling the cruising power of the ship. The two division officers should alternate in drilling the combined company at battalion parades, and each should drill his own division at other times.

In teaching sailors to drill as infantry, we must not waste time on superfluous movements, or in attempting to secure mechanical precision with the manual, or in wheeling. It sometimes seems as though the marine guards of our ships partially counteract their undeniable usefulness in other respects by offering an example of rigidity in marching which is as much out of place on a ship's deck as it would be on a field of battle. While we must teach position and marching carefully, to correct the defects incident to a seafaring life, we must not attempt to imitate the Marine Corps or the crack regiments of the

National Guard. We may even be compelled to look abroad for practical military models, as well as for the tactical instruction which we need to fill out the bare framework of our accepted drill-books. It is well to know the exact position of each marker and guide in all evolutions, but it is also necessary occasionally to assume the possible presence of an enemy, and regulate our formations and marching with some regard to his position. There must be something to learn, to bridge the gap between the manual which usurps the name of Tactics and the formidable technicalities of military strategy. The methods of training infantry used in the German army, as described in various papers in the proceedings of the Royal United Service Institution, seem to furnish the information required.

On board ship we can only teach simple methods of passing from line to column and the reverse. Skirmish drill can be taught to small detachments, and the use of cover, advancing by rushes, and other practical matters, can only be taught on the rare occasions when the battalion is landed. These subjects, with a very few movements in company front, are all that can be allowed to interfere with the effort to teach the men to march steadily and without fatigue. Reasonably rough ground should be preferred for these exercises, instead of the streets and squares usually selected. Dress parades should be rare indulgences either on shore or aboard ship, but they should not be altogether cut off. A band and a crowd of spectators will often render much aid in developing military instincts among sailors.

Skirmish drills on shore should always be based upon the idea of an attack on an enemy's position, which should be marked by flags or by targets for field-firing. These arrangements should be made beforehand, and company officers should reconnoitre the ground before the companies land. Blank cartridge may be used to give more steadiness in firing, and ball cartridge for field-firing at targets posted to represent an enemy's force. This would serve to teach men to judge distances as in actual warfare, and to seek cover in advancing. Trained marksmen should be told off to estimate distance and fire trial shots. These exercises may be carried on independently by companies or by the battalion, skirmishing by numbers in the latter case.

In preparing to land the battalion, the equipment should be by companies rather than by boats. Men must carry their supplies, and they can be distributed with less confusion on board ship than on the beach or in the boats. Battalion formations should frequently

terminate with the actual embarkation of companies in their proper groups of boats.

It is impossible to make fixed rules for the equipment of boats for any particular service with the idea of showing them all off together in five minutes or in half an hour. Actual requirements must govern the outfit for each case. The new ration should be able to furnish provisions in convenient packages, and the distribution of men by messes should secure the supply of mess gear for each detachment, with a cook to each boat to look out for it. The arrangements for feeding men on shore must be tested from time to time by actually giving men one or two meals on shore or away in boats. Soup or coffee could be carried in mess-kettles and the dry part of the ration in haversacks for a single day's absence. Such tests are necessary if our outfit of boats is to be anything more than a sorry farce.

As a means of carrying out such tests and giving practical military instruction, divisions or companies should be landed to camp out for a day or more in suitable positions. Forty-eight hours spent in camp in this way would give more time for deliberate target practice, skirmishing, sham fights, etc., than can be utilized in a year's cruise where men must return to the ship for meals.

It would also furnish much-needed variety and recreation, and would be preferred to the ordinary "rough liberty" for twenty-four hours by the best elements in our ships' companies. Of course climate must be carefully considered and hygienic precautions strictly enforced under the supervision of a medical officer. Discipline should also be secured by proper orders and properly posted guards, who should be held to a strict military responsibility.

This recommendation may meet with objections based on other grounds than discipline and hygiene. It may be urged that division officers cannot be spared without interfering with the harbor watch, or that men cannot be spared without interrupting. It is sufficient to say that all these difficulties must be encountered and overcome in actual practice. Landing an efficient naval battalion is often the only means by which bloodshed can be averted or the honor of the flag vindicated. The events which followed the bombardment of Alexandria will illustrate this statement. No mechanical routine and no traditional precautions should prevent the practical training of an efficient organization for landing.

Combined boat exercises should be simplified both in regard to outfit and evolutions. Not much can be learned by officers or men

by going through the complicated, rectangular manœuvres of the signal-book. In action they would be as useless for boats as for ships. For landing men only two or three evolutions are necessary, and speed in pulling is more important than accurate dressing in line. Pulling-boats should never lie on their oars under fire, and should not carry guns with any view of firing while making an attack. Rapid-firing guns in swift steam launches are the only weapons which boats can use against an enemy armed with modern weapons. Gun-boats must do their part in keeping back the enemy, or landing in the face of an enemy will be found impracticable.

The real use of combined boat exercises seems to lie in affording opportunities for training crews in pulling or sailing in competition with others. Divisional boat exercises are necessary to prepare them for such competitions, as well as for a variety of essential military uses. Boat-racing should be encouraged and extended so that nine-tenths of a ship's company will not be restricted to betting or boasting as their only part in the sport and exercise.

For military duties, as guard or picket boats, steam launches must be used as far as possible. Pulling-boats may be armed and assigned posts to complete a cordon, but launches must be relied upon for the active work. Divisional boat exercises should be directed to training relief crews for torpedo boats, guard boats and torpedo catchers. Every modern cruiser should have one real torpedo boat of high speed and one handy and seaworthy steam-cutter for towing and guard duty. Neither class of boats should be assigned places to manœuvre in line with pulling-boats, but should always act independently. Unwieldy passenger steam launches should not be carried by men-of-war. Ships should be ready to furnish relief crews for torpedo boats of all classes which may be in use in the service.

The control of all exercises, which will remain with the captain and executive, may be most judiciously exercised by frequent inquiry and inspection, to ascertain results and comparative progress. Uniformity of method is of less practical importance. Any division officer who desires to carry on a special drill of unusual length should state his plans to the executive at least twenty-four hours in advance, in order to get permission to keep the men. The navigator, being relieved from all care of a division, should inspect all ordnance material regularly and take the deck during drills, as at present. He should receive full reports in regard to the drills of each division, and should keep a full register of drills for the inspection of the captain. This record should con-

tain the character of each drill, the time occupied, the number of men present and excused, and such remarks, records of times, etc., as may be appended in explanation. A summary of the drill register might be sent in as a quarterly report, copies being retained on board for presentation at general inspection. It should not be the object of such comparison to secure exact compliance with any arbitrary routine, but rather to make sure that a reasonable amount of practical instruction has been given.

VI.—Conclusion.

This paper must be brought to a close without any attempt to summarize its arguments or suggestions in detail. Among the specific recommendations which may be noted are the following:

1. Complements as large as berthing accommodations will allow.

2. Divisions equal in force and efficiency. The number of divisions to regulate the detail of line officers.

3. Physical training and preparation for service as the objects of seamanship drills.

4. Regular watch drills in port and at sea.

5. Competition to be directed to finished results, including changes of rig for different kinds of service.

6. Gun divisions stationed in two reliefs, with sets of ammunition passers.

7. Aiming drill and target practice as the principal exercises, with all arms retained in the service.

8. Magazine rifles and machine guns to be the ordinary arms for all forces sent on detached service.

9. Exercises on shore to include camping, field-firing, and skirmishing over rough ground.

10. Boats, especially steam launches, to be prepared for special service by varied methods of equipment and exercise.

The accompanying arguments may be found unnecessarily discursive and aggressive, and the suggested details of various or uncertain value. The problems of naval reorganization and reform are too large and too intricate to be solved by any individual expression of opinion. Suggestions, rather than solutions, are set forth in this essay. The writer may have failed in formulating opinions which will stand the test of time or the criticism of his brother officers. From such failures not even official programmes are exempt, and this paper assumes to be nothing more than a personal contribution to the discussion of a professional question.

If charged with the atrocious crime of being in earnest, the writer will hardly be able to offer a general denial. It would have been easy enough to keep within the limits of superficial safety by adhering to accepted methods and elaborating comfortable commonplaces. It has been thought right to make explicit and radical suggestions of change at the risk of giving advantages to whatever opposition may be provoked by the obviously and necessarily critical form and manner of this paper. Active and earnest discussion must prepare the service at large for important changes of routine. Without such discussion, the systems devised by boards or bureaus will fail to be accepted or assimilated in practice. If the Naval Institute succeeds in stimulating this discussion, it will confer a great benefit to the future of the Navy.

The leading novelties which have been presented are, in nearly every instance, in practical operation in foreign services. This does not guarantee anything except their practicability under certain conditions, nor is it urged as a final argument for their adoption in our own service. The principal labor in writing this paper has been in selecting and adapting such measures as appeared to be best suited to the peculiar conditions existing in the Navy of the United States.

There has been no intention of laying down an absolute and inflexible routine for all ships of modern type. Such an attempt would involve a disregard of the facts and tendencies of recent naval progress. Until these tendencies become fixed in direction, drill and organization must be more or less experimental. Individual responsibility must be encouraged to assist the development of higher forms of discipline and efficiency. Absolute uniformity of method is bound to check the process of evolution. Comparison of results must be substituted for exact control of methods to secure progressive improvement. There is little danger that such a change will produce a greater variety in standards of efficiency than is now brought about by laxity and lack of interest in regard to warlike contingencies.

The training of officers for command must always be recognized as an object of organization and drill. The development of individual responsibility is an indispensable factor here. Officers must learn to decide questions arising during exercises according to their own judgment within certain limits. The instinct of subordination must not be cultivated at the expense of responsibility and habits of decision. The chief object of professional education is not to teach

officers to take exaggerated precautions against imaginary dangers, but rather to prepare them to accept necessary risks with coolness and confidence in their actual resources and in themselves.

It has not been found practicable to suggest changes without making those incessant comparisons which are apt to be considered the most odious forms of criticism. Unless we can say with full conviction, "The old is better," we are bound to criticise and compare, to eliminate the obsolete from our established methods. This attitude is not inconsistent with respect for constituted authorities or for the experience of the past.

Those who share with the writer the conviction that we need to transform the methods as well as to renew the material of our Navy, may sympathize with the purposes of this paper without accepting his conclusions. In spite of the reactionary routine which we are compelled to practise in our ships, and the traditional theories which we are expected to recite on examination for promotion, there are some believers in naval progress who cannot help standing up, like Galileo after his recantation, to say of our little world, "It moves for all that." This essay ventures to assert this principle of inevitable progress and to attempt its application to the details of organization and exercise for modern men-of-war.

APPENDIX.

SAMPLE ROUTINE.—PORT.

May to November.

4.30. All hands. Hammocks, 15 minutes; coffee, 15 minutes.
5.00. Turn to. Scrub clothes, 30 minutes (clothes soaked in fresh water overnight).
5.30. *Starboard watch* scrub spar-deck, ladders, etc., 1 hour.
Port watch clamp down gun deck or superstructure with hot water, 40 minutes. Bathe, 20 minutes. *Watches to alternate.*
6.30. *Port watch*, seamanship drill and squaring yards, 30 minutes.
Starboard watch bathe, 20 minutes.
6.50. Spread mess-gear.
7.00. Breakfast.
7.30. Shift into uniform of the day.
7.45. Turn to. Spread awnings, roll back hammock cloths, etc., 15 minutes.
8.00. Colors, lower boats. Clean gun brightwork, 30 minutes.
8.30. Clean deck brightwork and sweep down.
9.00. Quarters. Inspection of armament, 15 minutes.

9.30. *1st drill call, 2 divisions great guns.* Stations and pointing, 30 minutes.
2 divisions infantry drill. Aiming and squad drill, 30 minutes. Company drill, 30 minutes.

10.30. *2d drill call, great guns, infantry drill,* } as above. Divisions alternating.

11.30. Sweep down.

11.45. Spread mess-gear.

12.00. Dinner.

1.00. Turn to. Sweep down.

1.30. *3d drill call.* Boats. Torpedo instruction or skirmish drill, 1 hour (Monday, Tuesday, Thursday, Friday).

3.30. Pipe down scrubbed clothing. Sweep down.

4.30. Muster starboard watch at stations for next morning's exercise.

5.30. Supper.

Half an hour before sunset, spar drill for all hands.

WEEKLY ROUTINE OF GENERAL EXERCISES.

Monday.—General quarters, 9.30 to 10.30 A. M.

Wednesday.—Sail or spar drill, or combined boat exercise, 9.30 to 11.30.

Thursday.—Battalion drill. Equip for landing, 10.30 to 11.30.

NOTE.—In winter, no exercise should be held before 9 or after 4. At sea only one drill call should be sounded; watch drills at 11 A. M. and 3 P. M. being substituted for divisional exercises.

DISCUSSION.

U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

May 12, 1886.

Captain N. H. Farquhar, U. S. N., in the Chair.

Commander H. C. Taylor.—*Mr. Chairman and Gentlemen*:—There seems to be but slight opening for any save favorable criticism in the suggestions of the essayist. It occurred to me, before reading this excellent essay, that the question proposed was difficult on account of its vagueness; for what are "our war ships of latest type"? If such painful doubt has presented itself to the essayist, he has skilfully set it aside by suggesting changes which are very valuable for war ships of either old or new types.

He strikes boldly one of the keynotes of our defects when he says that we prepare only for "little wars peculiar to colonizing nations." It is indeed true that we prepare only odds and ends of a fleet, when a complete naval force would cost but little more in the long run than these present odds and ends.

The suggestion that a proper relation between the number of officers and the fighting force of each ship be established and maintained, is a most valuable one. I think it an excellent plan also that all commissioned officers should have deck duty in port; nor do I believe that the plan of keeping harbor night watches in a pilot house would meet with such vigorous opposition as the essayist fears.

The protests against superficial and showy drilling deserve the careful attention of all officers. Especially true and worthy of consideration also are the essayist's remarks upon handling steamers as a warlike exercise, and his statement that the problems of handling modern ships under steam are as varied as in the days of sail power. At this point, however, I fail to perceive that the most important element of success is dwelt upon by the essayist. I refer to that familiarity with the open sea which comes from training constantly at sea. If we can have steam cruisers and steam training ships kept as long at sea as the sailing ships, then I see clearly that the steamer practice is the more valuable, and can agree with the essayist that our present training squadron is obsolete. But so long as steamer training is confined principally to sheltered waters, and a cruiser waits for weeks to get a smooth day outside for target practice; so long as we permit the approach of bad weather rudely to interrupt sea manœuvres, while we make speed for the nearest harbor; so long, in fact, as we avoid the persistent sea drilling which is absolutely necessary to successful sea fighting—then, for just that length of time our present training squadron is not obsolete; and everything that is learned by a steamer's crew about a new ship, engine, or gun in the quiet waters of Chesapeake or Narragansett Bays, is more than balanced by that unconscious acquiring of the *sea-habit* by the crews and officers of those old sailing ships. When steamers will drop targets over in bad weather, cast loose their batteries in a half gale of wind, learn their

tactical diameters with a heavy sea running, find out practically how much sternway their ships will stand in such weather; when they will practise ramming and work their torpedoes and machine guns with a topping swell on; when, in fine, they will *use* on the open ocean the tools meant for ocean fighting, and do this habitually as their every-day navy work—then, and not till then, will the usefulness of our old sailing ships have passed away.

Turning to other portions of the essay, I note that the present loose system of powder divisions has been thoroughly grasped by the essayist, and believe that much good may result from his instructive suggestions concerning it, and concerning the defects in our present methods of target practice.

To touch upon all the good points of this interesting essay would occupy unduly the time of the Institute, but I would ask permission to notice one statement which seems to me unsupported by the evidence. The essayist refers to boarding as an improbable event in the future.

Now, if ramming is to be attempted in fleet engagements, as is quite certain to be the case, it must often happen that ships will find themselves, whether they wish it or not, alongside of enemy's ships. Efforts to ram, and efforts to meet or avoid the blow, must frequently produce this result; and in such a situation I do not see what other course than boarding or being boarded is open to us. It seems to me that our crew would suffer less from the enemy's machine-gun fire, if they were on the enemy's deck engaged in a general *mêlée* with his people, than if they remained on board our own ship. Do away with swords and pistols, if desirable; replace them with bayonets and magazine rifles, if they are better; but not because boarding is obsolete, for few things seem more certain than that boarding is to be a marked feature in fleet engagements of the future. It played a great part in the galley period, and became less prominent when sailing ships came in and ramming was not practicable. Now, under steam, we revert in many ways to the tactics of the galleys. Ramming will again be known, and boarding as its inevitable consequent.

Commander HORACE ELMER.—*Mr. Chairman and Gentlemen:*—Since first the subject of the present prize essay was proposed by the Board of Control, I have looked forward with interest to the result. The subject seemed to me not only important, but timely. It was fair to assume it would be published, with the accompanying discussion, by the time the new cruisers were ready to be commissioned. It was a practical subject, calling for a practical solution, and it was thought that such an expression of the views of the service at large might be of some value to the fortunate few who are to have the privilege of organizing and drilling the first of our new cruisers.

That the subject was proposed by the Board of Control would indicate that the necessity for change was recognized, and it hardly seems necessary for the essayist to have devoted so much time and space to prove this fact.

There is much in the essay that seems to me admirable—many valuable suggestions, many things very well said, and some others, perhaps, that might as well have been left unsaid. But, with all its details, sometimes very minute in matters of drill and routine, I think the commander and executive officer of the Atlanta will not obtain from this essay any very great assistance in their

labor of organization. That the division should be the basis of organization I believe, and agree with the essayist thoroughly; but with that statement, though frequently repeated, he virtually stops. To make such a change effective, far more radical changes will be necessary than merely messing the crew by divisions. The present system of parts of the ship must be given up; the number, title, duties, and character of petty officers changed; the gun captain should become the standard of selection, not the accident, as heretofore. All these questions will meet one who attempts to organize a ship's company on the basis of the division, and it seems to me they are more to the point than discussing the advisability of calling all hands to send down royal yards, when none of the new cruisers will have royal yards; and, whatever may be their "feeling of toleration" for the old drills, I have no idea the officers of the deck of the new cruisers will spend many of their leisure hours in light breezes, tacking or even chapelling ship. Therefore, it seems to me that all this onslaught upon certain forms of seamanship drills, necessarily obsolete in the new cruisers, is wasted ammunition, and I feel sure the essayist will find, throughout the service at large, far more general agreement than he seems willing to admit with the principle that all drills should be established with a practical purpose in view.

With the one important change in the detail of organization advocated in the essay, the abolition of the powder division, I do not agree. An improvement in the character of the powder division is certainly desirable, but it seems to me that in the future this division will be of much more importance than in the past. All the larger of the new cruisers should have, and probably will have, an ordnance officer, having special charge of the ordnance, ordnance stores, torpedoes, and electrical apparatus. This officer, in my opinion, should have charge of the powder division. The stowage, care, and delivery of ammunition are matters of the first importance, and should be under the charge of one competent, responsible officer. Were it practicable to have separate magazines, shell-rooms, and percussion lockers for each division, the scheme proposed by the essayist would have strong argument in its favor; but, by looking at their plans, it is evident the new cruisers have not been arranged with any such scheme in view. I have made these remarks with no desire to be captious, but because, though in some matters of drill the essayist has gone largely into details, in the more important matter of organization he has, in my opinion, but skimmed the surface, and the question as proposed by the Institute still remains, in its more important part, unanswered.

Lieutenant R. R. INGERSOLL.—*Mr. Chairman and Gentlemen:*—That the Prize Essay for 1886 is a very comprehensive and able paper, I think can hardly be questioned. That the changes proposed are a necessity, because of the introduction of new-type ships, is, however, not very clear. The suggestions will apply, with few exceptions, with equal force to our old ships, of whatever type. This should perhaps be a matter for congratulation, rather than for complaint, since nearly every feature of the scheme may be adopted at the pleasure of commanding officers—if, indeed, very many of them are not already being carried out—and our old ships can be modern in organization and drill, if not

in other matters. I think no one will dispute the general spirit of the essay, —that all organization and drill should be carried out with a view to possible emergencies of weather or battle, with a definite standard of excellence to attain, and that all other exercises should be subordinated to those which have these definite objects in sight. There may be many of us who believe that the present system of organization and drills has been carried out with a view to possible contingencies so far as obsolete material will permit, but it will probably do us no harm to agree that the definite objects should be kept more distinctly in view in the future than perhaps they have been in the past.

It is to be regretted that in his scheme the essayist has not told us what relation his quarter bill bears to the watch bill, since he does not change the latter. What shall be done with the large class of men not now assigned to gun divisions, and known as idlers? What should be done by a modern man-of-war in clearing for action, and what preparations should be made to avoid the consequences of ramming or collision?

The scheme for drills offers but little for criticism and much for commendation, especially the suggestions in regard to aiming drills and target practice, which are excellent. No definite system of recording great-gun target practice has been recommended, however, and while the essayist dwells upon the importance of keeping such records, he does not enlighten us as to the method of scoring or of plotting the fall of the shot. The plan of observing the fall of such shot by two observers having given very good results at the Naval Academy and elsewhere, I think, for want of a better plan, that could be used with benefit.

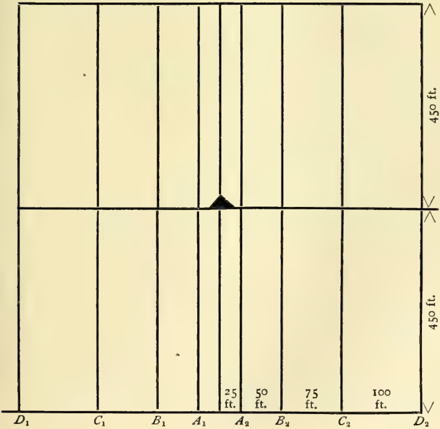
I understand the object of this discussion to be to bring out all the points possible, as well as to talk of the features that the essayist has advanced. With this understanding, then, I venture to suggest the following as a scheme for determining the size of diagrams for scoring target practice at any range and for any arm. It is perhaps unnecessary to say just here that target practice without plotting the shot and a study of the diagrams made is a waste of public money.

I assume, first, that the normal target for high-powered great-guns should be a ship 300 feet long, 50 feet beam and 20 feet above the water line, and at a distance at which guns of the sort we have in mind would be used in a naval action with a probability of many shot hitting; and I assume, further, this distance to be 2000 yards. When we have accumulated sufficient data from the firing of high-powered guns, this distance may be modified. Now, it is not practicable to have a vertical target 300 feet long by 20 feet high, so all we need is a small target, yet of sufficient size to be seen clearly at the range used, if we suppose it to be placed at the centre of the ship at the water line. In plotting the fall of the shot around this target, no positive value should be given in the score to a shot that would not hit the ship, so we have a maximum lateral limit to the target diagram, or 150 feet each side of the target. The ship, when end on, presents a minimum target, so the lateral limit for which maximum values can be given is fixed—viz., the half breadth of the ship, 25 feet on each side of the target. Take points half way between the target and maximum limits, or 75 feet, for the limits for which one-half the maximum value

can be allowed. For the dimension of the diagram in the other direction, I think first it should be taken on the horizontal plane, because a better comparison is afforded and less labor is required, a very small error on the vertical plane becoming large with high-powered guns on the horizontal plane.

The limits of the target diagram, then, on the horizontal plane should be the overestimate and underestimate that can be made with a high-powered gun when the true range is 2000 yards and still hit the target at some point of its height. These, in the case we are considering, and when the gun is aimed at a point its own height on the vertical target, say 10 feet high, will not be less than 150 yards; so our target diagrams for plotting target practice should allow for an error in range over and short of the target of at least 150 yards. For shorter ranges the lateral dimensions of the diagram should be diminished proportionally to the range, but the dimensions for range should not be changed, because with flat trajectories the errors in range for the same error in sighting rather increase than diminish as the range is diminished.

Let any value, say 20, be given to shot which fall within the lines which represent the ship end on; within the next lines 10; and the minimum value 5; then have a space 100 feet wide within which zero would be given; then give negative values to shot which fall without according to a fixed scale. The diagram would be like the following:



Hotchkiss guns should be judged by scoring on target diagrams representing the dimensions of the objects against which they will be used, such as torpedo boats 120 feet long by 12 feet beam, etc. Certain errors in gunnery practice belong to the gun alone and not to the gun captain. These could be ascertained at proving grounds, and should form a part of every range table. It is evident that the minimum dimensions within which shot plotted should have the maximum value should not be less than the errors due to the gun alone in range and direction. Practice at speed can be plotted and scored without serious error, provided the fire is delivered when the ship is near a line joining one of the observers and the target; this will require more time for practice, so that it can be plotted on rectangular diagrams, but it is believed that such diagrams better represent the effective work of the gun than when circles are used.

I think the sea or floating target recommended by the essayist is not a good one, for the reasons that if it is intended to be large enough to show the effect of firing against ships, or to encourage the men by showing a large number of hits, that it is not large enough, and it is so large in another sense that it is very unhandy. I think the target used by the Standish for three years past is the best I have seen for the purpose for which a target should be used; that is to say, to represent a point at which to aim and large enough to be clearly seen at all distances for which we need to use it. The Standish target consists of a float made of a square framework with diagonals, and is built of 4-inch pine scantling; the sides are eight feet, and a step is fitted at the centre of the float for the target pole. The target has four wings of *black* muslin, the same size as the regulation target. This target is simply hove overboard from the rail of the steamer, and has never once capsized, although it is often launched when going full speed. It does not require weights or barrels. It floats perfectly upright in a half gale of wind, and can be seen when smoke or haze would render a white target nearly or quite invisible. The expense attending target practice with service ammunition will probably result in the fitting of some sort of apparatus in the axis of the bore of large guns to fire Hotchkiss or small-arm ammunition. A reduced target to represent a ship 300 feet long by 20 feet high, at a distanee of 2000 yards, if a vertical target must be used, at a distance of 100 yards from the gun, would be fifteen feet long by one foot high. If the gun sights are used, it will not be so easy to hit as at first sight may seem, and if the records of each gun and gun captain are kept and studied, valuable data can be obtained even with small-arm ammunition, and at small expense.

Copies of the records of all great-gun target practice should be kept with the ship, as they would afford the commanding officer knowledge of what his guns and gun captains can do at different ranges, and such knowledge will go far in influencing his decision as to the best range to begin an action.

The perfection of details of any plan of organization and drills can only be obtained by trial; and while many details would seem desirable in connection with so comprehensive a plan as we have before us, yet I think the essayist has given us much food for thought in those which he has submitted.

Lieutenant D. H. MAHAN.—*Mr. Chairman and Gentlemen:*—While I have listened with great interest to Lieutenant Calkins' paper, I must say that I think he does not go far enough into the matter, and I think his changes in organization and drill can be improved upon. One of the principal faults of our present system seems to be that a man has too much to remember. There is no system of association—that is, there is no attention paid to the simplifying of the work by causing one position to have a direct bearing upon other positions in drill. We station a man around according to the fancy of the executive officer. A man may be in the first division, third cutter, second howitzer's crew, and in the launch at "abandon ship."

I would suggest that two organizations be allowed, and no more—one to be known as the fighting organization, the other as the seamanship organization. The first to comprise under its heading the company, division, boats, artillery, and, as it has boats then, of course "abandon ship"; the second to have all the evolutions connected with the handling of the ship, its spars, and sails. As soon as the ship is cleared for action, then the seamanship organization ends and the fighting organization goes into effect.

Take the company as the basis of the fighting organization; the company to consist of forty-eight men and four sergeants. Allow four companies to a first-rate, three to a second, two to a third, and one to a fourth. Lieutenant Calkins needs only forty-five men to his divisions, so seven extra men will not be amiss. These companies should be put on board as the fighting complement of the ship, and should not include any non-combatants. Divide the company into two platoons for artillery drill, two pieces of artillery to each company: thus, you can drill them as infantry, artillery, or as both. Put this one company into two cutters, to be known as first cutters starboard and port. At boat exercise you will have a company in two boats, a platoon in one boat, and a piece in each boat if necessary. Have this company to form the first division for ship-fighting. This division would then have sixteen ammunition passers instead of nine—none too many. The divisions should be arranged on board ship as companies are arranged in battalion—in other words, having four divisions, a senior forward, then a junior, next a junior, and a senior aft. It must be remembered that the captain, executive officer, and navigator are going to have as much as they can attend to now. So forward and aft should be the proper positions for the seniors. I would station the men so that a man in the first platoon of the first company would be in the first artillery crew, first cutter starboard, and first division; and, still more to render his memory less burdened, I would have the first set of fours as the first set forward on the drag-rope, first set forward in pulling boats, and filling the first places at great-guns, so that a man will associate No. 1 front rank, first set of fours, with No. 1 at piece, No. 1 in boat, and what is now first loader at gun. The men will thus be continually working together, will become accustomed to each other, work better, and more quickly become accustomed to their places.

As Lieutenant Calkins suggests, it is desirable to have the ammunition passers belong to the different divisions. The powder division should consist only of the men stationed in the magazines and shell rooms. Now that ammunition

passing has become the most important work of all, we no longer want Chinese, bandsmen, and ignorant servants to control the supply of ammunition.

Outside of the fighting organizations we find quartermasters, coxswains, berth-deck cooks, messmen, idlers, and engineers' force. It would be well to reorganize the petty officers. Make them a distinct set, and so separate them from the rest of the ship's company as to give them positions and authority such as sergeants and corporals have now in the Army. There should be two distinct sets of petty officers, with two grades of pay, and they should have a different uniform from the men, and at the same time not so different as to render them too conspicuous in action. They should be appointed by a board of officers, and only be disrated by sentence of a court-martial. In the first grade should be quartermasters, quarter-gunners, and coxswains ; in the second grade boatswain's mates, captains of parts of ship, ship's cook, ship's corporal, etc. The quartermasters should be young men, intelligent and quick. Coxswains should be chosen from the intelligent men of the ship's company, and should be a sort of acting quartermaster, having charge of boats to which they may be assigned, and of the ammunition passers in their divisions under the officer of the division to which their boats belong. At boat drill, have a coxswain with two boat-keepers in each boat, to look out for the boats when the battalion lands. In the seamanship organization, these coxswains should look out for the rigging and gear on deck. Quarter-gunners should have a complete knowledge of small-arms and mechanical guns, as well as of ammunition. The boatswain's mate, and captains of parts of ship are placed in the second grade, as they do not now require so high a degree of intellect as those selected for the first grade. Berth-deck cooks should be shipped for the purpose ; have charge of berth deck and around galley, hoist coal, pump water, etc. There are altogether too many idlers on board ship, and they are all too well paid for the duties rendered. The engineers' force, besides their regular duties, should be instructed in small-arm, Gatling, and Hotchkiss guns, so that they could assist in defending the ship during the absence of the landing party. The firemen should rank with seamen of the first rate and seamen of the second rate. There is no reason why the inequality of pay should exist amongst this set, although it may unjustly exist amongst the junior officers. The only seamen of the third rate on board the ship should be messmen, coal heavers, and berth-deck cooks ; so we have seamen of the first rate, seamen of the second rate (formerly ordinary-seamen), and seamen of the third rate (formerly landsmen).

To promote this organization, officers ordered to a ship should go to her with the understanding that they are to make the cruise in the ship, not to be transferred to other ships, and only to be relieved from duty by cause of sickness, sentence of court-martial, or by orders from the Department. On an officer being relieved from duty, his place should be filled by one of his own rank and, as nearly as possible, about his own number. Such an arrangement will add to the content of all and give renewed interest in the discipline and efficiency of the whole Navy. Can you not realize why an officer changed from ship to ship, from division to division, soon loses some of his interest in the

work? A change can also be made in the way of duty. Continual walking the deck and keeping spit-kids in line becomes monotonous after many years. In port have an officer of the day in charge of all. To be always ready for a call, allow him to turn in from 10 P. M. to "all hands" in the morning. If you will not let him sleep, let him read and smoke: if you see him smoking you will know he is not asleep. But the one thing above all others that must be done is to clear away favoritism and political influence. So long as these two hold their present power, no organization can be perfected.

Lieutenant BARRY.—*Mr. Chairman and Gentlemen*:—After reading this essay I must confess to a feeling of great disappointment. I fail to see an answer to the question propounded, and upon careful examination, the essay, to me, seems mainly to be made up of words put together like one of Mr. Gladstone's replies when he does not wish to answer the questions of the Opposition. Except the rather vague suggestion that each division should supply its own ammunition, I fail to see a new idea advanced. For years the platitudes herein contained have been subjects of discussion throughout the Navy; and many of the numerous aphorisms easily can be reduced into more platitudes.

As to a practical application of theories. In a professional sense, the Civil War was the greatest misfortune that ever befell our Navy. Without even an elementary knowledge of military comparison, our politicians have been blinded by the results attained, and even to-day, Congressmen apparently sane on other subjects, continually are informing the country that when needed we can create a Navy as we did in 1861! How can we be expected to handle ships properly in actual war, when in peace there is no opportunity afforded for practical exercises? Were it the only definition of seamanship, "handling vessels in fighting condition, that is, under full steam power," would be what we want; but other and contradictory definitions are given elsewhere. Of these later.

As regards naval administration we are between two fires—efficiency and economy. Congress represents the economy, and the Department has to take its cue from the amount of available cash. I know I am talking treason when I whisper against the great efficiency of the Navy; but I venture to say the service would be ten times as efficient if there were money available to pay for extra coal and other expensive items required for practical battle drills; hence, our experimental and practical work is limited: we must cut our coat according to our cloth; though I hope the day never will come again when the captain of a filthy, slouchy ship will be complimented because he had never expended all his "allowances"!

I do not think it was the intention of the question to obtain a theoretical Utopia, but to get an answer showing what can be done for our modern ships and with them. What are these ships of the latest type? The essay fails to tell us. To be sure, the Chicago and Atlanta types are named, but the rest of the paragraph tells us "they are intended to have speed and handiness, and their batteries have been selected and disposed with a view to enable them to choose their distance and to fight without surrendering all the advantages of speed and manœuvring power." This means simply that they belong to the

modern type, and the definition will cover the greater number of foreign naval constructions during the past ten years.

The second part of the question, and the most important part of it, is, What is to be required of them? In fact, this is really the main subject of the discussion. Is there anything in the essay to show the nature of their future duty? To fight, of course. But to fight what? Under what conditions? Where? What to do when not fighting? Are they coast defenders, or so-called line-of-battle ships, or are they cruisers? What kinds of wars are we likely to be engaged in? What kinds of naval operations are these vessels likely to be engaged in? Surely, to use anything "most effectively," it ought to be prepared—first, by finding out what it is intended for; secondly, by adapting the means to the end.

As to seamanship. The essayist defines seamanship "as the art of sailing ships effectively." This, while true of sailing-ships, contradicts the extracted definition first referred to. It is too narrow, and failed to be correct even as early as the second period of nineteenth-century development, when steam became a factor. To-day no commanding officer will allow his vessel to be endangered through failure to get up steam. In time of war, if his engines and boilers are not in a condition to do this, his ship has no business to be out of port. An officer is called a good seaman when he can *handle* a ship effectively under all circumstances, in port or at sea; or, better still (for this is meant by "at sea"), when under way. In a recent discussion of a kindred subject, Commodore Russell defined seamanship as "simply a thorough, ready knowledge of the duties to be performed on board a vessel at sea." Excluding from this gunnery, navigation, steam engineering, and interior economy, no better definition can be asked. It will be seen readily that the seaman of to-day, be he officer or be he man, differs materially from the Benbows and the Tom Coffins of other days.

In any well-regulated ship the development of the strength and activity of the ship's company, with reference to health and discipline, is not dependent upon the presence of spars and sails. In mastless ironclads this can be and is accomplished. The essayist seems to appreciate the absurdity of all this when he says (and to my mind it is the happiest and best hit in the essay) hundreds of men are called on deck to lower three little spars (the royal yards) as the colors are hauled down. This calls to mind the statement, years ago, of an influential officer that at the time defeated the introduction of steam capstans: "When you call 'all hands up anchor,' what are the men to do?"

Without discussing the question of the status of our mercantile marine, I venture to say that, unless vastly improved before our next war, the "traditional naval policy" will find, as it would find to-morrow, nothing in our merchant fleet capable of performing the duties of a man-of-war. Until too late, and when the enemy is thundering at our gates, our traditional parsimonious naval policy, coupled with many other causes, never will permit the use of merchant steamers as proposed; nor, as in England, their special construction. With us this is Utopia, but not feasible.

We next come to the apprentice system. While not properly a subject for

discussion under the question propounded, it seems to me the remedy proposed is worse than the disease. The real cure lies in reward. As continuous-service men, we never get back the very best apprentice graduates. Why? Because they always can find something better to do. This matter was discussed fully in a former prize essay, and needs no further reference. Is (naval) life worth living? Answer it in the affirmative, make it so, and the problem is solved.

Concerning sailors as infantry, it seems to me it would be well entirely to separate sailors from marines. At the very best, seamen never can approach the rigid infantry of Frederick the Great. When a small force is landed, the use of "rigid infantry," as such, manifestly will not be needed; when a large force is landed, enough marines can be gathered together to make up the soldier element; sailors will then devote themselves to skirmish and artillery work—their only efficient work when on shore.

"We need trained men to serve as gun captains, file closers and coxswains"; but what connection is there between a gun captain and a coxswain, or a file closer? I think we can be accused of the worship of the seaman. Practically we say: "A good seaman is good at everything." Let us make gun captains gun shooters, and let coxswains of boats stay with their boats; anybody can be a file closer. What are the requisites for marksmanship? By no means does it follow that a good musket marksman can shoot straight with a cannon. The vital need of our ships and of our future gun captains is target practice. We need a corps of gun captains—men that can take charge of a gun; and we never shall have them so long as we make Tom or Dick "Captain of No. 3" because his watch number puts him there. Gun captains and top captains should have no connection. The principal duty of the latter is to "wash down"; the principal duty of the former is to shoot correctly.

To supply ammunition, the essayist would use the divisions and do away with the powder division proper. If he have a magazine for each gun, the duty of the old powder division will be done by a vastly superior force, and I think less efficiently; if one magazine supply powder, who are to be *in* the magazine? Is there to be one man from each gun, or just enough properly to handle the powder? If metal tags are to be attached to projectiles and to charges, who regulates their number? If a gun be disabled, can other guns make use of the "tallied" charges? Confusion and delay are sure to result. Does not the idea suggest itself that rapidity in the delivery of *projectiles* will remedy all the evil? Powder can always be supplied more rapidly than it can be used, but, with the increase of weight and size, projectiles must be delivered more rapidly at the battery. Increase in the number of shell rooms and the use of steam hoisting will produce the needed rapidity.

The essayist says of drills, "Uniformity of method is of less practical importance"; and of reports, "It should not be the object of such comparison to secure exact compliance with any arbitrary routine, but rather to make sure that a reasonable amount of practical instruction has been given." With this I beg to differ. I do not wish to be understood to say it is impossible to arrive at the same result by more than one method, but I submit, with all due deference to the powers that be, that one of our most crying evils is want of

uniformity; squadrons drill according to the will of the commander-in-chief, ships as the commanding officer wishes; and if division officers are to be encouraged in the same direction, individual caprice can go but little farther. The essayist seems to recognize this when he says later, "Officers must learn to decide questions arising during exercise according to their own judgment *within certain limits*"; which always has been conceded by the most ardent advocates of uniformity.

For the information of the essayist, I wish to state that the Copernican theory was taught first prior to 1464, by Cardinal Nicholas of Cusa; in 1504 by Copernicus, and in 1616 by Galileo. The famous recantation was made in 1633. As taught by Nicholas and Copernicus, this hypothetical theory continued to be taught after Galileo's death. Galileo's main proofs have been demonstrated false. Sir Isaac Newton was the first to demonstrate the truth of the theory. "It moves, for all that," has less foundation in history than Wellington's *spoken* remark, "Up, Guards, and at them!"

I close by asking if the executive officers of the Chicago and the Atlanta go aboard with this essay in their hand, how much will it aid them in organization, and how much will it aid them and others in drill?

Lieutenant CHARLES R. MILES.—*Mr. Chairman and Gentlemen:*—I find very little room for comment of a purely critical character upon that part of the essay relating to the proposed changes in drill, but upon the changes in organization proposed by the essayist he has not made his position so invulnerable. He has advocated one change under this head that I fear may prove a stumbling-block in the way of one of the most useful branches of our service, and I cannot remain silent and permit his views upon that point to pass unchallenged. I refer to his proposition to keep up "on a *reduced* basis" our present system of training apprentices.

Perhaps some apology ought to be made for taking the time of the meeting in discussing a part of the essay wherein the essayist seems to have strayed away from the subject somewhat; for I take the subject as given out by the Institute to refer to the changes in organization of the ship's company, and not to the changes necessary in the organization of the Navy. As the essayist, however, has made the subject elastic enough to include the reorganization of the present system of training apprentices, I feel that I am not altogether responsible for the digression.

I am sure that most of the officers of the service that have been associated with the intelligent American youths sent out from the training school will agree with me in according to this most useful branch a place of first importance in our naval establishment. That there are defects in the present system, I shall not attempt to deny; but upon the implication made that one of these defects consists in its having been established on too extensive a basis, I am prepared to take issue with the essayist. It may appear true, on first thought, that the numerical results of this attempt to Americanize the Navy are more or less of a failure; for probably not more than ten per cent. of the apprentices re-enlist immediately upon the expiration of their apprenticeship.

But I claim that this percentage does not represent the whole number of men of this class in the service at any given time, as many of those that retire to civil life undoubtedly meet with reverses, and in time drift back into the service. The essayist also seems not to have considered the valuable reserve force furnished in time of war for the Navy to draw from, by this very class of men that have retired to civil life—a class much superior to the raw levies that the Navy was obliged to accept to man its ships at the breaking out of the Civil War. I will venture to assert, therefore, that our Government would not lose by the bargain, should it increase this training service to twice its present basis ; for, besides the increase in continuous-service men obtained, and the increase of the valuable reserve just mentioned, it would get from two to three years' service from every apprentice on board of the regular cruisers—a period during which, as has been satisfactorily proved, these apprentices would perform most acceptably the duties of ordinary-seamen, seamen, and, in exceptional cases, even the duties of petty officers. I believe the average apprentice of the 1st class to be superior in every way to the ordinary-seaman of former times, if we except their capacity for physical endurance, perhaps ; and every apprentice of this class, when he becomes eighteen years of age, but not earlier, should be sent on board a regular cruising ship.

If the numerical results of the training service do not meet with the approval of the essayist, I wish to remind him that the fault lies not in the present system of training, but rather in the fact that sufficient inducements to remain in the service are not offered by the Government to these valuable trained men. In many cases, also, the officers with whom they are thrown after leaving the training ships take no especial interest in them, and as no attempt is made to wed them to the service, many naturally never learn to feel themselves an integral part of it, but, on the contrary, welcome the time when they can retire to civil life. I have in mind a case in point: An ambitious young apprentice, a leading boy on board one of the apprentice-ships, was sent to a regular cruiser, and there, for nearly a year, he was kept on duty as a messenger. Was it a wonder that his spirit was broken ? or that he displayed what little spirit was left in him by endeavoring to get his discharge ? I contend that a proper system of service pensions, better pay for petty officers and skilled men generally, and, finally, though not the least to be considered, juster treatment and a fairer estimate of the value of these trained youths by the officers with whom they serve, will bring about all that can be desired in regard to the numerical results of the present system.

In regard to the "mariners" or "naval volunteers" proposed by the essayist, I fail to see that the inducements offered them to remain in the service are any greater than those now offered to the apprentices ; and, after much time has been wasted in training these raw recruits, I fail to see that we should possess any guarantee that they would not also retire to civil life at the end of their enlistment and thus produce the same inadequate numerical result complained of under the present system. The nautical habit and the love of a profession like ours are acquired early in life, and in a vast majority of cases at an earlier age than twenty-five. American boys, trained in the service and growing up with

it, will give us a patriotic and powerful fighting force of which in time we may well be proud. The man at twenty-five years of age that has not already chosen a profession will prove of little use to us, except in the performance of those simple menial duties that are usually performed on board ship by this same class of men at the present time.

The present system of training men, although yet in its incipiency, has proved itself one of our brightest jewels. Let us not be too critical about the details of the system, but let us unite, one and all, in assisting those that are engaged in the work by giving them our thorough co-operation and good-will.

Lieutenant C. D. GALLOWAY.—*Mr. Chairman and Gentlemen* :—I think the Institute and the service at large are to be congratulated on having received such a concise and lucid paper on this important subject. I believe from this article a compendium of rules could very readily be made which would improve the present methods, and which would wipe out much of the present routine nonsense.

As to what the essayist defines as seamanship, I take exceptions. Seamanship, in my opinion, is the correct care and handling of a vessel, no matter what her rig or motive-power may be, whether at anchor or under way among shoals or among other vessels ; in gales of wind or calms ; at single anchor, moored, or with springs on cables ; either during offensive or defensive manœuvring, or while making passages. There can be but only one higher type of seamanship than that of conducting a ship from port to port at the great speeds now developed. The nerve required for such work, the judgment required in navigating her in bad weather and in good, is seamanship, and the kind that should be cultivated by all officers. The one higher type I have referred to consists in correctly doing what should be done when disaster does come, as shown by the way the vessel and crew are handled, and the most made of every device that can relieve the distress of the vessel, by the readiness of resource and exposition of nerve that have been previously cultivated.

As the opportunity now offers, I should like to say something upon the remarks made by the essayist on the subject of training seamen, and of the faults found by him in the present system. It is a lamentable fact that many of the best-trained apprentices do leave the service after reaching their majority, but some of them return after a short time ; others would probably come back in time of war. In fact, I know that some of them return denying that they were ever apprentices, owing to the treatment received by apprentices on some ships. Many more of them would re-enlist within three months, if permission to go on shore and to draw and spend their own money were more freely allowed.

I think that all good-conduct men and apprentices should be allowed to go on liberty in our own ports, at least, either in citizens' clothes or in some plain dress similar to that allowed to yeomen, writers, and others. There can be no objection to it but prejudice, and perhaps the difficulty of identification in case of attempted desertion or straggling. The latter reason can have no weight, however, as in cases of this sort the uniform is readily exchanged

for old clothes, the "clean blue mustering clothes" being thus entirely lost. I am sure, from what I know from my own observation and from the opinions of fellow-officers, that such a simple change would keep many more men in the service: the reasons being that men in seamen's clothes have the doors of nearly all decent places shut to them, from barber-shops to churches. They are marked men, and the prey of sharps and runners. Their friends avoid them in public, and they are cut off from many of the amusements and pleasures open to a much lower class of society in civil life. Their pay is sufficient to enable them to have such clothes, and their more expensive blue clothes would thus be saved. I insist that this simple change in costume would encourage many men to remain. Much more might be urged to strengthen this argument, but it would be out of place here.

Officers should encourage the feeling that a seaman's position is an important one, and that each man is a very important part of the country's defense, an upholder of its honor, and his station much superior to many in civil life. If we can by fair treatment, and by giving good pay and good food, make our seamen proud of their position, of their ships, and of their flag, many more apprentices will remain in the service, and the more remaining, the higher type of crews we shall have, thus eliminating the weakest features of the present system as mentioned by the essayist. In the effort to retain good men in the service, attention should also be called to the classification and pay as shown in the Navy Register. To the eye of a layman the value of an article is to a great extent judged by its moneyed value, and to one glancing over that list it will be found that the actual fighting force of a ship's company is the least valuable. Compare any of the subdivisions, from petty officers, first-class, to seamen, third-class, and the result is the same. A chief gunner's mate gets less pay per month by ten dollars than a writer; a gunner's mate less than a cook, musician, or carpenter's mate; a captain of forecastle or top less than a painter, an oiler, or a printer; a seaman less than a lamplighter, a tailor, or a barber; and yet wonder is expressed that many apprentices fail to remain in such a service.

It seems to me the strongest means should be taken to encourage apprentices to remain, rather than to accept the essayist's idea of getting older men. The efforts of all officers, therefore, should be exerted to attain this end.

Lieutenant E. H. C. LEUTZE.—*Mr. Chairman and Gentlemen:*—As much that I intended saying has already been anticipated by those that have preceded me, I will only add that in making changes in the organization of our vessels I think it is necessary to begin at the top—that is, with the officers. I think with the essayist that it is high time that the lieutenants of our Navy should be relieved from the onerous and deteriorating watch duty which they have to perform in port. The junior officers who now are without definite status in regard to duty, could, if necessary, perform that service as well, if not better, not having lost all spirit and ardor by years of monotonous tramping up and down. If necessary, one of the lieutenants could be on duty for twenty-four hours as officer of the day. The lieutenants should be required, however, to

pay more attention to their divisions and have more frequent drills. One of them, I think, should be detailed as ordnance officer and have immediate charge of all articles pertaining to the battery, magazines, torpedoes, etc. It will probably be urged that the navigator will be able to perform that duty. In my experience, however, the navigator has plenty of work to keep him busy, especially, as being "the man who has nothing to do," he is ordered on every court-martial, board of survey, and any other duty outside of the routine that is to be performed.

While on this subject, I would like to put myself on record as being firmly convinced that it would be for the good of the service to have all commissioned officers in the wardroom. I would almost say all officers, but see many reasons why naval cadets should live by themselves. I think steerages are not only uncomfortable, unhealthy, and unfit for matured men to live in, but are positively indecent. Ensigns and those of assimilated rank are older men now than those of twenty years ago, many of them being married men, and these gentlemen are certainly entitled to some privacy and a spot where they can indulge in serious reading or study. We all know that they can have opportunity for neither in the steerage. They are sent on board ship and thrown in close contact with youngsters just turned loose from school, who may have been their pupils, or whom they may examine at their final graduating examination. I think the tone of both wardroom and steerage messes would be improved; the older men would become more dignified, and the younger, less frivolous and, perhaps, more respectful in their remarks about their seniors.

If it should be said that there is no room in the wardroom, then, as the steerages have to be retained for the cadets, I think it would be the lesser evil to knock down the bulkhead and take all officers into one mess. The breaking up of this one mess would also rid the ship of two non-combatants.

Lieutenant CHARLES BELKNAP.—*Mr. Chairman and Gentlemen*:—I think that in proposing this subject for the prize essay, the Board of Control of the Institute had in view the Chicago, Atlanta, and Boston, the only vessels we have at all modern; and since these vessels must rely entirely upon the gun for their offensive power, I regret to find that the essayist has not outlined a more definite plan for the changes in organization needed to exercise that power most effectively. The organization we now make use of has come down to us, with a few modifications, from the days when the weather gage was considered of the utmost importance; but under existing conditions the watch, quarter, and station bills should be made out with sole regard to the end in view—the development of the offensive power.

In regard to the changes in drill, I do not agree with the essayist in extending, if I understand him aright, the scope of individual idiosyncrasies. There cannot, perhaps, be too much uniformity in putting the principles of so exact a science as gunnery into practice. The disadvantages of latitude seem to be tacitly admitted by the essayist, as he discourages changes among divisional officers. Were the practices carried out uniformly, a change of divisional officer could produce nothing more than physical effect.

To gain uniformity in exercises, the Ordnance Manual should, in the first place, be rewritten, separating it perhaps into two volumes. In addition, each ship after being put into commission should be placed under the instruction of the Ordnance Bureau until a thorough course of exercises should have been gone through with, involving all the varied circumstances in the uses of the offensive weapons on board. With headquarters in Lynnhaven Bay, for example, the ship could put out to sea, perform the various exercises under direction of an officer specially detailed for the purpose, returning daily to the anchorage, where targets could be carefully examined to show results attained, until all understood the manner in which the bureau wished the exercises carried on.

The results attained at different times during the cruise and before going out of commission would, by comparison, show the value of the course of instruction and exercise pursued.

I will not trespass any further upon your indulgence by indicating the series of exercises to be pursued; they naturally embrace all where hitting an object with a projectile is concerned. But such I believe to be the changes in drill and exercises needed to fight the new cruisers most effectively.

The Chairman.—Lieutenant Calkins is to be congratulated on being the first person to be twice successful in writing the prize essay. I am sorry, however, that he is not present to-night to answer for himself; no doubt, if he were, he would clear up much that seems obscure to some of those who have taken part in this interesting discussion. The paper has been so ably debated that little is left for me to say.

The Board of Control, of which I was a member, in selecting this subject, hoped to set officers thinking about the new Navy, so fondly hoped for. The seven essays submitted in competition show that its hopes have been realized.

It is evident that reorganizations of the *personnel* and drills are necessary to manage and fight properly the new ships. But I think the essayist loses sight of the modern improvements when he proposes to fill the ships with as large crews as they can berth. The effect would be, so to speak, to make too much food for the enemy's powder. The tendency of the age is to have machinery take the place of muscle; of machine guns to replace regiments, and of engines to "sheet home" and "hoist away," instead of hundreds of men to the music of the bugle. If there is a desire on both sides to engage, head-winds or calms will not prevent. The action will be of short duration; therefore, the ordinary crew will not be overworked. For the purpose of training men, the crews might be as large as the essayist suggests.

It is to be regretted that the author, while treating so liberally in generalities, has not gone more into useful detail, so that one might know how he would organize, equip, arm, and station a ship's company, and afterwards exercise it, and fight the battle.

On the motion of Commander Huntington, U. S. N., a vote of thanks was tendered to the Prize Essayist.

WASHINGTON BRANCH,

MAY 19, 1886.

Rear-Admiral EDWARD SIMPSON, U. S. N., President of the Institute, in the Chair.

Commander A. D. BROWN.—*Mr. Chairman and Gentlemen:*—I have jotted down a few points in the essay that attracted my attention in reading it, concerning which I propose to offer a few words, without attempting to discuss the paper as a whole. I think it may be said, however, that our author has given us a very good paper; certainly he has laid out a good deal of work for those who are to have the control of our new ships.

Reference is made to the training system and its inadequate supply of men, with the intimation that it is regarded as our only dependence for supply. I do not think this can be the case, for in the complement of the Atlanta there are 28 landsmen—a pretty fair proportion as things go.

I think that the essayist is correct when he says that there should be no marine officers with the guard. I see no reason why the relation to the ship of the officer commanding the marine division should be different from that of any other divisional officer; and the laws do not appear to contemplate the necessity that is supposed to exist for this being the case. If we can make no use of the nautical training of the junior marine officers, we are better off without them on board ship. I say this without disparagement to them or to the gallant corps to which they belong.

Again, our author says that "every man should belong to an efficient military organization"; in this I heartily concur, especially if he includes in the term *man* the officers as well. In a paper which I had the honor to read before the Institute some years ago, I said that "every officer, except the medical officers and the chaplain, should be a combatant sea officer, a graduate of the Naval Academy," and from the opinion then expressed I see no reason to dissent; in fact, the necessity therefor seems to be every day more apparent.

A caution regarding the position of the three senior officers in action is well timed; it might be a matter of some interest to ascertain the probable chances of the survival throughout an action of the gentlemen who are to occupy those honorable situations; it does not seem likely that all of them would be able to pass through the fire of machine guns unharmed, and I suppose that it would be a mere question of duration as to the officer upon whom the command would fall after an action was closed.

I am entirely at one with Lieutenant Calkins in his denunciation of competitive drills in which time is to be made; for I consider that there are no words too strong to apply to them; they foster careless and slovenly work, and are of no earthly good whatever, that I can see. "Gilguys and gadgets" are in the highest degree unseamanlike, and though I must plead guilty to having used them at an earlier stage, I must, in justice to myself, say that it has been only because the other fellow was doing the same thing without rebuke from our common superior. In general, the remark of the paper upon the subject of

the character of the drills to be pursued is excellent, and many of the suggestions might be carried out to advantage in our older ships.

It is evident that there is a spirit of improvement abroad in the Department, for we have recently seen the North Atlantic Squadron displaying its naval power, or rather its want of that power, in a series of drills which, while they seem to have had a good deal of the time system in them, yet must have been productive of much knowledge on the part of all concerned, especially that portion of the officers who rarely have an opportunity for handling their ships under way. More of this should be done as suggested.

It occurs to me that we have presented to us an excellent plan for the service of the ammunition; certainly none could be much worse than the present one under which the powder division is exercised. I remember to have heard our honored president say that "the powder division was the most important one in the ship," and, if I am not mistaken, in one vessel commanded by him it was placed in charge of the senior instead of the junior watch officer. At all events, I should like to have the proposed experiment tried in the Atlanta, to see whether it is the improvement I think it.

It seems to me a matter for regret that we are obliged to have so large a proportion of our force afloat belonging to the non-effectives; in our ships the ratio is, I believe, higher than in any other service; and this state of affairs is continued in the new ships. In the Omaha and Atlanta the proportion of the different branches is as follows: servants, 10 per cent.; special, 14; engineer's force, 20; battery and spar deck, 56. While it does not seem reasonable that there should be 24 per cent. of almost entirely non-effectives, yet it will require the exercise of great judgment on the part of the authorities to reduce this ratio; and perhaps I may say a great change in the ideas of officers, both in command and in inferior positions, to cause a proper disposition of the force placed at their disposal. I am sure that the number of servants could be materially decreased without any sacrifice of the comfort of the officers, while adding materially to the efficiency of the ship; and this is, I think, the first place where the pruning-knife should be used.

The essayist is not far out in his estimate of the number of men that the Atlanta will have. According to the present complement she will have 193, exclusive of marines, the engineer's force being 41. If we go back to the old fashion of having but two watches in the fire room at quarters, there will be left 163 men from which to draw the four divisions mentioned; from these must be deducted five for the surgeon, leaving 158; of these there are 19 servants, 11 engineer's force, 8 artificers, 14 first-class petty officers, so that the number of reliable men from which to draw is greatly decreased; still we would be able to have the divisions almost as large as contemplated. The second relief would not be a full one; with that exception the plan could be carried out, and I think that it is certainly worth trying.

I cannot close these brief remarks without saying that I think we make altogether too much of watch standing, and that to exact port watches is calling upon men to do too much. Where all the line officers are standing watch there would be no need for doing duty in this way; it fosters the idea so very preva-

lent, that when one is over his day's duty he is off until the next tour begins—a most pernicious doctrine, which leads one to forget that the first duty of every officer is to the ship upon which he is serving, and that practically speaking that duty is (like that of the executive officer) never done. Our ensigns are of the age at which the lieutanants of the war period, and immediately after, did their duty; and many of them are as old as are some of the captains now on the list when they held their earliest commands during the war. It will be observed that our author does not propose to lessen, but rather to increase the amount of work to be done, and therefore the change in the method of standing watch is an essential portion of his scheme. In three watches (where there is so great a misfortune) an officer of the day would be all-sufficient. In conclusion, I desire to tender my congratulations to Lieutenant Calkins for the manner in which he has enunciated his views, and I hope, with him, that they may prove of practical benefit to the service.

Lieutenant-Commander C. H. STOCKTON.—*Mr. Chairman and Gentlemen:*—This essay is found to be most interesting, being critical and suggestive, and, to a less extent, constructive. Taking the treatment of the subject, as given by the Naval Institute, as the matter alone to be discussed—*i. e.*, the changes in *organization* and *drill* that are necessary to sail and fight most effectively our war ships of the latest type—I find the changes suggested in *organization* are few in number and to my mind not too radical.

They can be stated briefly as follows:

First.—The equalization in numerical strength of the divisions; the union of the effective men of two divisions as a company of seventy-two men; with provision for relief crews and ammunition passers as an integral part of the division.

Second.—The consequent abolition of the powder division.

Third.—The change of the navigator's division into a division of equal numerical strength as the others; but with duties in addition to their former ones of riflemen and of working the rapid-firing guns of the tops, etc. This division to be in charge no longer of the navigator.

No decrease in numbers of the men on board is favored, except in the number of servants, but a complement which will fill the ship without crowding is advocated. An additional system of classification is also urged, making proficiency in drill the basis.

I agree very decidedly with the essayist in the idea mentioned of equalizing divisions. This has been done, and is done to a great extent at present, and the advantages of having such units in organization can be readily appreciated in the formation of companies of infantry, sections of artillery, boats' crews, messes, etc. When practicable—and from our knowledge of the possibilities in these ships it seems feasible—I think all will assent to its advisability.

In regard to the suggestion of the formation of a company of seventy-two men from two of the divisions, I cannot but regard it of doubtful utility; besides the breaking up of the divisional unit and placing the men under an officer of another division, the advantages of a smaller company of from thirty-

four to thirty-six strike me as greater. Besides being formed of the effective men of one division, under their own officers, it is a smaller unit, less unwieldy, occupying less boat space, and, hence, less likely to be scattered, and in addition also feeling more strongly and directly the personal influence of the officers and of divisional companionship.

The provision for relief crews and ammunition passers, and the abolition of the powder division, in my judgment is a good one, and tending to increased efficiency in the working of the battery and service of ammunition. It provides in broadside guns for the manning of each gun in an efficient way, besides furnishing trained men to replace deficiencies caused in action. As for the ammunition supply, as proposed, it is more under the control of the officer most concerned, renders the division independent and self-supporting, and the interchangeability of the men will make the division, I think, in every way stronger.

The change in the navigation division I think most excellent; and in addition would suggest the placing of the marine guard and its officer as an integral part of this division, to do the duty of sharpshooters and riflemen, and man a portion of the guns in the tops. From recent experience I found that the marines were sufficiently active and serviceable aloft for that duty; and as we have shaped the sailor into an infantry man without making him a soldier, I think we can readily station the marine aloft, and give him sufficient flexibility without attempting to make him a sailor. The marine guard as ordinarily drawn up at general quarters only serves as a most tempting target for machine guns.

The argument in favor of a complement that will fill the ship is a strong one, and in marked contrast to the reduction of complement suggested by Commander Glass in his recent paper published by the Institute. No matter how improved and how great in number the mechanical appliances on board may be, there should be an effective force for landing purposes and detached operations, the absence of which should not entirely disable the ship. It is a simple impossibility for military detachments or wandering transports to do the work liable to be demanded for the emergencies that may arise, and which can be so well and readily met by a large or small force from a cruising war ship.

In regard to the classification of the men according to their training and drill, it seems a move in the right direction, and opens up possibilities, in a far-reaching way, of a substitution for the present system of classification according to seamanship alone, based as it often is upon service in the merchant marine of a character entirely foreign to naval duties.

The changes proposed under the second heading—*in drill*—can be summarized as follows:

First.—Drilling by watches in port.

Second.—Abolition of competition among ships for the first six months of the cruise.

Third.—Greater attention to aiming drill and marksmanship in general.

Fourth.—The abolition of the cutlass and pistol and their drill.

And as minor changes: The working of the guns at daily inspection, and the establishment of four rigs.

More extensive drilling by watches in port is desirable, and is, I think, more practicable in our newer ships. It has its limits, and the writer has, I think, reached one extreme in his proposed drill routine for the morning watch in port. For reasons suggested in the essay, it would be most beneficial, while not absolutely abolishing competition, to limit it to two or three drills in that time, so as to enliven the ship as a whole at rare intervals.

The importance of much greater attention to aiming drill, though strongly stated, cannot be too forcibly urged, and its value cannot be overestimated.

In regard to the cutlass and pistol, in my opinion the cutlass is a thing of the past as a gymnastic exercise. Its drill is inferior to the pure gymnastics as practised in the French Navy. The pistols furnished to ships, with which I have had experience, I think can be dispensed with as of little value, though I admit the value of a good weapon, well handled.

The daily working of guns at inspection I consider a decidedly good plan, mechanical carriages and appliances making it almost necessary. A visit to the Esmeralda a year ago, at Panama, showed the carriages there in bad condition, with the more delicate parts badly rusted, and an evident neglect of constant manipulation of the mechanical appliances.

The rigs, suggested and classified, though not novel, can be usefully combined, and the provision for their use in the system of signals can be readily made.

An omission of sufficient stress on ship-torpedo drill is noticed. No matter how indifferent is the plant with which we are supplied, we should have our men more frequently drilled. If the system is radically bad, the application of the maxim in administration, that "the best method of securing the repeal of a bad law is its enforcement," might be of use. These torpedoes are still manufactured and supplied, and that fact encourages the vague reliance placed upon them by the outside world.

In regard to what is said about the apprentice system, I have been so unfortunate as to have no exact knowledge of how matters stand, and what the statistics are upon the subject. I should not like to form or advance any opinion from the very limited field in active service from which I could alone judge. In addition I have discovered only general statements of an unofficial nature that do not cover the whole ground. How large the number that graduate each year into the service is, and what the cost *per capita* of each so entered, I do not know. I hope we shall be able to get the statistics of the system, and not have to depend upon generalities alone, more or less glittering though they be.

Lieutenant W. H. BEEHLER.—*Mr. Chairman and Gentlemen*:—The admirable essay under discussion seems to cover the ground so generally that it is difficult to find many features which will not meet with general approval. There are, however, a few points which might have been more thoroughly elucidated in order to offer practical suggestions to remedy the evils of our present organization and drill.

Certain changes in regard to the classification of our enlisted men are suggested, but they do not go to the root of the subject. The organization of the *personnel* should be completely changed in order to meet the growing requirements of the service. The essayist claims that the apprentice system has failed, and in lieu thereof suggests that "young men of good physique and intelligence" be enlisted and given "a rapid course in military training while they are acquiring the rudiments of seamanship by serving in cruising vessels."

This is, however, the aim of our present system. I believe the true remedy lies in lengthening the period of enlistments and to have each re-enlistment a graded sequence of the preceding. The present system of continuous-service men is an effort in the right direction, but the chief consideration in view is to provide pay and certain emoluments as a bounty for re-enlistment, while but little account is taken of the professional attainments of previous enlistments. The latest types of war ships require a specially trained *personnel.* The man-of-war's man of the present is not merely a sailor, but must be a skilled artillerist, a well-drilled infantry soldier, a machinist, a torpedoist, as well as a sailor, qualified for all kinds of strictly nautical work, such as boatman, topman, helmsman, etc.

The period of five years is necessary for efficient service in the Army and Marine Corps, where only one or two of the foregoing qualifications are required, and surely this term is absolutely necessary for the Navy. Not that a cruise should be for five years, but that the enlistment be for that term. The first and last years of each enlistment should be spent on shore in barracks at the navy yards, where a much more efficient course in military training can be given, rather than while serving in cruising vessels. This would leave two-fifths of the entire enlisted *personnel* on shore and three-fifths in the cruising vessels. This, however, is not such a radical measure as would seem, as there are about five thousand men (generally less) serving in the ships on the *five cruising stations*, exclusive of the boys, while the entire force is seven thousand five hundred men. The essayist presents no scheme for a prompt mobilization of a reserve, because none is contemplated, whereas this plan enables the mobilization of a reserve equal to two-fifths of the entire Navy. In the present time war follows upon the receipt of telegraphic information, and the necessity for an immediately available naval force is the most striking feature of the times.

The organization should be thorough in all details. Each man should be enlisted for a certain ship; the ship should make a three years' cruise, and be held in reserve during the first and last years of every period of five years. The crew could then live in barracks while their ship is in reserve, and except when undergoing extensive repairs will be available for immediate service, with reduced complements, perhaps, owing to temporary absence of the deserving on leave for portions of this period. This reserve would supply a needed organized naval brigade at each naval station for any emergencies.

The classification suggested by the prize essayist is not sufficiently thorough in providing for a regular graded promotion of the men to petty officers and warrant officers. The petty officers should all be regularly graded, and em-

braced in different special branches, so that proficiency in one grade should lead directly up to the next higher; then on to and including that of warrant officer. For example, captains of tops to become boatswain's mate; then chief boatswain's mate; then boatswains; ranking respectively as corporals, second sergeants, first sergeants, and warrant officers. The torpedo *personnel* should, in like manner, have graded petty officers such as might be: Torpedo mechanic, torpedo mate, chief torpedo mate, torpedoist, with relative rank of non-commissioned and warrant officers respectively. All the unorganized *personnel* of petty officers can be so grouped with relative rank that the status of every man may be thoroughly defined as in one of the following branches—viz.: Gunners, boatswains, masters, artificers, torpedoists, machinists; and the remainder, such as baymen, apothecaries, writers, cooks, stewards, and storekeepers, be assigned the relative ranks of non-commissioned officers, not to reach the grade of warrant officer. This will introduce two additional branches of warrant officers—viz.: torpedoists and machinists; the titles of carpenters and sailmakers being changed to those of artificers and masters. The masters-at-arms and ship's corporals should be selected from the *personnel* in the boatswains', gunners', and masters' branches of warrant officers, and permanent petty officers. The difficulty of obtaining such men will be obviated by the adoption of some plan like this. The duties of the master-at-arms and ship's corporals are such that they must be good seamen in order to have the personal respect of their shipmates. The occasional detail of those so qualified, as will be ascertained from properly kept records, may be considered as a sort of detached duty for the cruise of the ship to which they may be assigned. Some such system must be introduced in our organization if we ever hope to Americanize our Navy. Americans are ambitious to occupy positions of trust and responsibility, and this scheme affords them some chance of gratifying their ambition as warrant officers. It does not pay Americans to ship.

The petty officers should be permanently attached to the Navy, and all those who reach the grades of first and second sergeants should have their names in the Navy Register. A certain amount of pride in the service, together with a permanent interest in the welfare of the Navy, will ensue, and contribute very much to Americanize the Navy. There is no hope for much improvement in the individual status of the enlisted men in our present organization. The enlisted man is no better off after a cruise than before, except, perhaps, by a little experience and a small sum of money, which is immediately squandered. Our present organization is the chief obstacle in the efforts to obtain young Americans for the service.

The five-year term of enlistment will also contribute, as explained, to improve the *personnel*. When a ship is commissioned her crew will have had a preliminary training of one year. No vacancies will have to be filled by enlistment of foreigners when on the cruise, and all the evils attending the wholesale discharge of men immediately after their return from a three-years' cruise, and the expense of extra pay for overtime men, will be obviated. The continuous-service certificates would have to be modified to suit this change in the period of enlistments.

The equalization of divisions in force and efficiency advocated in the essay sounds well, but it is practically not as feasible in the latest type of war ships as in the obsolete types in sail at present. The essayist seems to overlook the chief features of the modern war ship's armament: the primary battery of high-power breech-loading rifle, the secondary battery of rapid-firing, multifire and machine guns, and the torpedo armaments. He does not provide for any torpedo division, as if it had been definitely decided that the pot on the end of a pole is to continue to be our only torpedo armament. It is true that we have no other torpedoes yet, but then we have no modern ships, either. The organization of a torpedo division, comprising the trained torpedo *personnel* to manipulate the torpedo-launching tubes, cannot be placed in command of a divisional officer on the battery deck, otherwise fully occupied by his duties in charge of the battery.

The proposed abolition of the powder division I consider a very wise measure; but the reasons and advantages of the change are not fully specified, though a little reflection will satisfy almost everybody of the necessity of having the ammunition supply of the guns under the control of the gun divisional officers.

Some other features of our organization are not referred to in the essay, such as fire quarters. Only a few changes in the details will be necessary for the latest types of war ships. The present practice is therefore sufficient. There is, however, nothing said about the necessity, arising out of the great speed of a modern war ship, for having an organized detail for "Collision Quarters." The most prolific cause of disaster is undoubtedly what may be classified under collisions, including all accidents, such as grounding, colliding with other vessels, and shipwreck. The liability to collisions is much greater than hitherto, because of the great speed by which only a few moments intervene during which ships meeting are in sight of each other. Collision quarters should be prescribed in our organization similar to the organization of fire quarters. This should be of such a character that every possible emergency may be thoroughly provided for.

The essay contains many valuable suggestions concerning the changes in the drills, and some features will not be accepted immediately. The necessity for more thorough and more elaborate aiming drills is very ably discussed, but I think it should have gone further, to include annual prize firing throughout the Navy. Substantial money prizes should be awarded for superiority in the contest, provided a certain standard be attained. This should be minutely prescribed by the Navy Department, and be uniform throughout the service. Some special, distinctive mark, as flying a peculiar dogvane at the main, may be authorized for the ship which wins the annual prize. The methods in vogue in the English Navy may be adopted with a few modifications.

I regret that there is so little said about torpedo warfare. This is now recognized as a most important factor, and there should be constant drill with fish torpedoes and submarine mines. Every ship should carry a complete system of submarine mines, with cables, etc., so that it would be possible for her to protect a harbor of refuge. There should be drills in laying out the system of mines, and drills for attacking them. Without this practice the mere announce-

ment that a place is defended by torpedoes will, perhaps, deter an attack which political reasons may demand as absolutely necessary. There is no definite plan proposed for defending ships against torpedo attack. The torpedo net is now recognized as the most effective means invented, and our ships should be supplied with it and their crews exercised in handling the net. I agree with most of the ideas suggested in this essay, but there should be a more thorough organization of the enlisted *personnel*, and provision for the drills I have enumerated, in addition to those advocated by the prize essayist.

Ensign W. L. RODGERS.—*Mr. Chairman and Gentlemen:*—As I have written an essay on this subject which is to be published, I feel at liberty to criticise the admirable one now under discussion without making any suggestions. The author very early says that "the services of the Marine Corps as a police force are invaluable and justify its continuance in spite of the want of adaptability of its system of training to nautical conditions." I prefer to invert and reverse the sentence, and would say that the want of adaptability of the Marine Corps system of training to nautical conditions justifies its discontinuance in spite of its valuable services as a police force. I have not the slightest wish to belittle the past great services of the Marine Corps, but the subject under discussion is the attainment of the maximum efficiency of our modern ships, and the question is whether men reach their greatest "all-around" usefulness and fighting efficiency for naval warfare when trained and organized as marines or as blue-jackets. For myself, I think that at the present time in our service the marines are better drilled, more reliable, and more efficient in their line than are our blue-jackets; but we will all acknowledge that a thoroughly good seaman well instructed in all his duties is a more useful man for general naval service than is an equally good marine. The blue-jackets at the recent encampments have proved reliable as police, and it is probably only necessary to trust them in order to find them trustworthy. As regards the special duties of landing parties, the marines are a small minority of the total force, and certainly we must admit that the French, who have no marines on shipboard, did not seem to feel their absence at the brilliant capture of Sfax. I would, therefore, conclude that as soon as we have a good body of blue-jackets the marines will be no longer called for.

The next point to consider is the organization as proposed for the Atlanta. In the first place the author proposes to do away with the powder division, alleging that the commanding officer cannot control its detached squads in time of action, and charging the well-known inefficiency of the powder division to this cause. It seems to me that the powder division is comparatively inefficient only because the executive is content to have it so. The author says that the officer of the powder division must be ubiquitous to ensure efficiency; but he seems to confuse the nature of his duties with those of the lieutenants of the gun divisions. The latter have to make their initiative felt at every moment of the battle; the former has merely to establish at his leisure a system which shall work mechanically in action, and this does not call for ubiquity. The confusion that would arise from each division procuring its

own ammunition must be very great, and I cannot see the weight of the arguments urged in its favor. The next point is that divisions should be of equal force and efficiency. It seems rather that equal force would cause unequal efficiency, for if we compare the first and second divisions of the Atlanta as proposed by the author, we find (neglecting the rapid-firing guns) that a round weighing 525 pounds is provided by nine men of the first division, while thirteen men of the second division provide a round weighing 300 pounds. If we consider the rapid-firing guns, the disparity in the service of the heavy guns is still further increased. The author then sketches out an organization for the Atlanta for a complement of two hundred and thirty men. It will be admitted that this is a sufficient complement, though not large. He sets aside fifty men for first-class petty officers, a small marine guard and a strong engineer's force. In the British Navy the horse-power per man of the engineer's force varies from sixty to one hundred and twenty, but for ships of the type of the Atlanta it is fairly constant and may be regarded as about eighty-five. This allows forty-one men for the Atlanta's engineer force, and adding four men that we may have a strong force, we have five men left for the first-class petty officers and the small marine guard. The remaining one hundred and eighty men are divided into four gun divisions, each forty-five strong, and the author states that the natural arrangement would be to put three of them to man the primary battery, leaving the fourth for the rapid-firing guns on the upper deck and in the tops, to assist in navigation and to act as small-arm men. When the Chilian ironclads captured the Huascar they had twelve men in each top. If we adopt this arrangement for the Atlanta and put two men at each Hotchkiss gun—one to load and one to fire—we will have five men left to supply ammunition to the Hotchkiss battery, to assist in navigation and act as small-arm men on deck.

But instead of the arrangement which he says is natural, the author adopts something else. He puts an eight-inch gun mounted *en barbette* on the main deck, a six-inch gun under the superstructure and two Hotchkiss on the superstructure, all in one division. The development of the use of voice-tubes and telegraphs advocated by the author must be carried very far to ensure to the lieutenant his control of such a division. What becomes of the fourth division in this organization is not apparent : either it mans the other two broadside guns, when there is no one left for the tops and deck work, or, as this seems contradicted by the context, it goes on deck as a division of riflemen, when it violates the principle of reliefs for each crew, and seems superfluous, as the reliefs of two divisions are already available as riflemen. But by a hasty examination of the probable distribution of the Atlanta's crew of two hundred and thirty men, I think that we may arrive at an important conclusion regarding the engineer's force. As I have already said, there will be about forty-five men in the engineer's force. The structural arrangement of the ship is such that at least forty-five will be required for providing ammunition : in a word, for the powder division. There will probably be twenty-five marines. This makes one hundred and fifteen men. If we place five men in each top and allow for five carpenters in the wing passages, and five first-class petty officers,

ten men for general service about the decks, signal men, baymen, etc., and three men for each of the eight Hotchkiss guns, or say twenty-five men, we shall have a total of one hundred and seventy men, leaving sixty men for manning the eight guns of the primary battery. It will be generally admitted that a ship should be able to detach half her force and still remain fairly efficient. Let us see how we can make up a landing force of even one hundred men. I will assume that thirty men can handle the primary battery upon emergency. We thus have thirty men to land. The powder division is already none too large, but let us take ten from it. The marines (twenty-five) will all go. One of the Hotchkiss guns on a field carriage with its crew may be able to make up twenty men from those in the tops and about the decks on general duty. We cannot take any one from the secondary battery, for they have none to spare. We thus have a total of eighty-five men. As the engineer's force is the one whose services are least likely to be urgently needed when a detached expedition is called for, the conclusion seems inevitable that it must be thoroughly trained as a combatant force and send a large contingent to the naval brigade.

Watch drills, I believe, have long been discussed in the service, and it seems strange that they have never been adopted, although they have all the advantages enumerated by the author.

As gymnastics seems to be the only object of the proposed exercise of squaring yards, it is worthy of consideration whether it would not be better to form a column of fours and double time around the deck for fifteen minutes every morning.

The use of single-sticks as an exercise is condemned by the author because it develops no interest or instinct among seamen. There are two excellent reasons for this: no masks are furnished and officers take no interest in the exercise. If these matters were remedied, it seems as if great benefit would follow from single-stick drill.

In regard to what the author says of the present method of standing watch, it is probable that the great majority of officers will agree. Officers should stand days' duty without regular watches when in port, for it is impossible for them to be thoroughly efficient and take a proper interest in drills and studies when they are compelled to spend on deck a large part of every night absolutely without object, except concession to custom. That the present method is really unnecessary is shown by the custom of other services, and by the fact that commanding officers, who alone are opposed to change in this respect, make it a general rule not to come on deck during the night, although they must be aware that officers are not strict about walking the deck, and thereby, as it is claimed, endanger the safety of the ships.

Mr. Beehler wishes to keep petty officers in the service, and hopes to do so by entering their names in the Navy Register. There must be given some more substantial reason than that. The English system has given excellent results, retaining a good class of petty officers, and as this gives a tried system ready for use, we might adopt that without seeking further.

In regard to what the author says regarding the closer association of officers

with their divisions I think almost all will agree; and in this connection I would like to suggest the advisability of making the quarter and other fighting bills more flexible by committing more authority to divisional officers. At the present time it is usual to have a most rigid connection between the different bills, and a man's gun and number at the gun, his boat and company, are absolutely determined by his watch number, producing results frequently unfavorable to fighting efficiency.

It seems as if fighting efficiency would be increased and executive officers would be relieved of much work by making the quarter bill the basis of organization, so that officers would always command the same men in any of the fighting organizations; and then the complete control of the internal organization of the division should be turned over to its commander, who should station his men at the guns and make the detail and organization of his company subject only to the Ordnance Instructions and such general rules as the executive officer lays down.

Commander WINFIELD S. SCHLEY.—*Mr. Chairman and Gentlemen:*—I would like to make a few remarks upon the subjects treated in this essay, but I will premise them by the statement that the essay presents itself to my mind as an extremely aggressive argument, though I endorse it as a whole, because I feel that it is absolutely necessary that assaults of this nature should be made upon that conservatism of our service that tends rather to retard what under modern development may not inappropriately be termed the new or higher seamanship.

There are some of the author's statements with which I cannot agree, particularly those in which he attacks the present training service and states that it has failed to produce continuous-service men, and therefore the system is a failure. If the essayist had known more of this matter under discussion, I question if he would have committed himself to such a remarkable utterance.

At the outset I ought to say that the training system of our Navy differs radically from that of the British. In England a large proportion of the population are seamen, and the main object of their training system is to secure a class of trained petty officers, while with us the decadence of our merchant marine has made it necessary to train our boys first to be seamen and subsequently to be petty officers. It must be seen, then, that the training process is necessarily longer, and much more time will be necessary before the absolute result can have been determined. When I state that present results to the service at large justify the statement that nearly 15 per cent. of the service comes from the training system, it hardly bears out the statement of the essayist that the system has failed; and when we remember that a fair proportion of the crews are composed of apprentices under training, the per cent. is apparently increased.

But a much better and broader view of this system would not ignore the great benefit and advantage which must directly accrue to the community at large. Though many of these boys may leave us at the expiration of their apprenticeship to improve themselves financially, there can be no doubt that

in the event of war many of them would find their way back again. Are not the masses from which these boys come impressed by the example of those who return in better condition than when they left their homes? Can a system be said to have failed which returns boys to a community disciplined and self-supporting? Does not the country directly benefit by having large numbers of boys already trained to the requirements of her defense whenever the time shall come for their need?

I think we can fairly trust that these trained boys will have patriotism enough to return to the Navy whenever the emergency may require them. If they do not, they will be very unlike most Americans.

Touching the matter of organization, I think that any one of our profession who has reflectively witnessed the wonderful advance of the last few years in constructing, in defending, and in protecting the modern war ship, must have observed that old types were giving way to new machines, and that new methods and newer instruments of all kinds were superseding the older; all of these changes mean that there are to be changes of organization, of training, and of preparation of the *personnel*, to adapt them to use on board the new type of war ships. All these things are just as certain as that the electric light has succeeded the tallow candle, and that a new education was necessary for the management of the former.

The fact that machine guns are so largely a part of modern armament indicates very clearly that the loss of life in future naval combats is to be infinitely greater than ever before, and this alone would appear to emphasize the necessity of obliterating all distinctions of corps as now organized. I think that every officer, except the surgeon, should receive such military education as will fit him to succeed to command.

A general order has just been issued by the Honorable Secretary of the Navy looking to the reduction in the non-combatant element on board our ships, which under old traditions had grown to 46 per cent. of the force on board such a ship as the Chicago. By this order all men belonging to the "artificer" and "special class" are required to be drilled in the use of great-guns, machine guns, small-arms, and all other implements of attack or defense. This order reverses old organization, and is but the beginning of a new system under which the Navy will be improved when it shall have had full effect.

What would be the effect of an attempt to justify the defeat of a national vessel by the statement that 46 per cent. of her men were untrained to her defense? Who could withstand the vengeance of the people if a ship still capable of resistance had been forced to surrender with nearly half of her *personnel* uninjured, but untrained to warlike uses, or unskilled in the higher seamanship of manœuvring or defending her?

It is these facts which ought to suggest change of adherence to or adoration for our effete organizations, and for one I accept the essayist's suggestions as a move in the right direction.

There is something to be said for the old drills, when it is remembered that their purpose was twofold: First, as a means to discipline and order in holding the ship's company under quiet control for two or three hours each

day; and second, as a means to secure uniformity and efficiency in working together simultaneously in performing evolutions with spars and sails that emergencies at sea often require done quickly and together. If "gilguys" are used to secure quickness rather than security, the fault lies more with the commanding officer who permits such makeshifts than with the system of drilling. My own experience in the various ships in which I have served as executive or commanding officer was to forbid such things. I always felt that the purpose of the ship's exercise was to secure the highest proficiency, and without the use of any "gilguys" it was accomplished to a remarkable degree. I always felt that nothing was well done unless completely and thoroughly done.

The essay is exceedingly discursive, so that in one reading it is impossible to take it all in; but my own thoughts for a number of years have tended precisely in the same general direction, until I was beginning to feel that I might be to some extent a "crank" in this matter. I believe in the march of progress now going on; that masts, except military kinds, and sails must disappear; they must go; and the plea of many that we are to be professionally injured when they do disappear, I do not believe to be tenable. In a great degree they have disappeared from the merchant service, and I am sure we find that service more efficient to-day and the carrying trade quite as well taken care of as in former days. I had the pleasure, last summer, of making a sea-trip in a fine steamer the mate of which had never served in a square rigger, and a finer sailor, with more nerve or fuller of expedients, I never met.

Let me compare the qualities needed by officers who have to drive their own vessels in a fog on to the coast eighteen knots an hour to make time with those under similar circumstances approaching in a sailing vessel at five or six. The judgment and nerve of the former are not comparable to those required in the latter. The former demands training to the men and higher seamanship, and without this skill the newer war vessels would be of no use.

The essayist refers to continuous-service men of the Navy, and allusion has been made to-night to the advantages of five years over three as the period of enlistment. I would state that there are to-day 7200 men afloat, and of this number there are about 3000 continuous-service men, and this appears rather a good showing. The period of five-year enlistments is a matter about which there has been considerable discussion. No doubt the custom of enlisting for three years grew from the fact that all the laws referring to re-enlistments have a three-year condition as necessary to secure the gratuities of pay. It is a question whether men would not be cut off from the three months' pay now accruing to those who re-enlist within three months after discharge, if the period were increased to five years with the law stating three as the necessary condition. It is at least certain that the law must be changed, and this you must all know is not an easy affair. I have made a number of suggestions to the committees all looking to the betterment of the condition of our men, but up to this time we have not succeeded in securing what appears to me so necessary. If any one present feels that the task is easy, I cordially invite his assistance. At all events, I understand now for the first time in my life how to reply to that constant inquiry in the service, "Why don't they do so-and-so?"

The essay as a whole is an exceedingly instructive paper. Though faulty in some particulars and epigrammatic in others, yet it indicates to my mind that there are others who think and believe as I do about the changes that are surely in sight for the new Navy and its organization. I can even see, in the new necessities that are to come with the new ships, that there will be changes in the names of such personages as captain of top, captain of afterguard, quarter gunners, and the like. These distinctions of title will be swept away, to give place to others that will better express the duties that men are to perform. This may seem extreme, but if we look backward for twenty years to the monitor days, there must come the conclusion that if we had continued to develop that class of ships, we would have long since substituted names and distinctions for the men who served them that would have expressed their duties, rather than have continued distinctions of title which belong rather to the traditions of the days of Trafalgar and the Nile.

Assistant Naval Constructor BOWLES.—*Mr. Chairman and Gentlemen:*—A greater familiarity with the arrangements of the Atlanta would have considerably changed the criticisms of some on the prize essay, expressed here this evening; and while I will not detain you with a description of the battery arrangements, still I would point out that six of the eight machine guns of the Atlanta are operated from within the superstructure. Those on the upper deck are not provided with fixed mounts. In fact, the battery is so arranged that the scheme of the essayist as to battery divisions appears practicable. It should not pass unnoticed also that the Atlanta is provided with an elaborate and complete system of speaking tubes arranged with special reference to the command of the battery and the supply of ammunition in action.

THE CHAIRMAN.—I think the essayist has every reason to be gratified at the manner in which his essay has been received; for it has attracted a great deal of attention. I wish now to submit a few remarks of my own, which will come in as a general review of the subject.

If the question that was propounded to the Institute had for its object the production of a definite system for "changes in organization and drill necessary to sail and fight effectively our war ships of latest type," I think the question was premature; if, however, it was intended as a note of preparation to put the Navy on the alert, and to direct the naval mind to prepare itself for what is coming by inquiry, it is very well, and our essayist has well performed his task. We are not sufficiently familiar with the ships to conclude definitely on changes in organization; we are not sufficiently familiar with the guns, carriages and implements to determine on changes in drill, or the number of men, even, needed to manipulate the batteries. We are dealing with unknown quantities, and we can lay down no rules until practice may develop the necessities. It is right, however, that the naval mind should be exercised on this matter in advance, and the result of the propounding of this question is most satisfactory in showing that the subject has the attention of many of our most thoughtful minds. The proof of this is shown in the number of essays sub-

mitted in response to the question—seven in all—a number, I think, larger than for some years preceding.

Not being in a position to lay down definite rules, our essayist has most liberally supplied us with suggestions apt for consideration when the time to apply them shall arrive, and there is an admirable thoroughness apparent in the manner in which he treats them. He certainly has proved himself guilty of the crime of earnestness, and has not hesitated to pose as a target for the shafts of criticism. He is right: this is a time of transition in the Navy, and old customs and traditions do not now obscure the merit of new ideas. Innovations are not necessarily condemned because they derange established routine; the spirit of progress permits a hearing to all. Some may be roughly handled in the clash of ideas, but the intelligent manner in which advances are made must lead us to the belief that sound judgment will control our decisions on all questions of change.

I think the reference made by Lieutenant Calkins to the necessity of increasing the complement of men for our new ships is worthy of consideration. It is very timely, too, and will apply to the old ships as well. All executive officers have of late years been at their wits' end to provide men for the performance of various duties, and this scarcity of men has led to a practice which Lieutenant Calkins objects to, and I agree with him, of calling all hands on every occasion of performance of any, even the most trifling, evolution. I endorse fully the suggestion to work by watches as much as the force will make it practicable. The number of the crew is needed to be increased at this time, even in our old ships, if only for working the secondary batteries that must be increased.

The idea of enlisting young men of native birth to the age of twenty-five years, irrespective of their knowledge of seamanship, allowing them to form a large proportion of the crew, is not new, and it is one that I have approved. To change the title of these men from landsman to volunteer or seaman cadet, or any other more appropriate, is, I think, a good idea. They should be on trial, as it were, for a short term, on duty in the North Atlantic Squadron, subject to discharge at any time if found undesirable, retained on good behavior, and encouraged by rewards if proving suitable and efficient. Our service is un-Americanized by only enlisting seamen. In spite of the higher pay and increased comforts, we do not now secure American sailors for the Navy, and the number of apprentices who re-enlist in the Navy is sadly small (the Brooklyn, lately gone into commission, had only six of them in her crew). The trial has not yet been made of shipping young men of twenty-five in large numbers, irrespective of their sea experience, for short terms, during which they can decide whether they will persevere in the profession or not. The knowledge that they were not bound for a long period would impose contentment even on those who concluded not to continue in the service. Although I am strongly in favor of a seafaring man learning his first lessons in a purely sailing vessel, and had hoped that the training service for boys would supply such for the Navy, I am forced to admit that the results do not meet my expectations. The young men of twenty-five years of age would commence their instruction in

ships where sails, ropes and spars occupy a secondary position; but their age and intelligence may compensate for what is wanting in primary instruction.

The subject of competition is well presented in the essay. It must be delayed until details are mastered, and it should not be reserved for ship against ship. It should be more encouraged in every ship. Working by watches will encourage it as watch against watch, and the different parts of the ship should compete with one another. The stringent application of this practice would logically lead to the abandonment of simultaneous crossing of royal yards and such-like evolutions, which are cited as illustrations of adherence to practices which militate against progress. It probably would need but the first plunge to reconcile us to such changes. The idea has been suggested before, but it stands a better chance now for the test of experiment. The adoption of such practices will show that the object of the exercise is achievement, not display. It would be in the same line of independence which we have assumed in the rig of some of our new ships, where we have asserted our preference for utility at the expense of conventional, seamanlike appearance. It may be that the time may come when the writer of the essay may be gratified even by having the "ceremonial of colors" divorced from "practical exercises in seamanship." The exercise that he proposes of four special rigs for harbor, sailing, steaming, and fighting is a useful addition to seamanship drills.

In relation to matters pertaining to action, whether with the battery, the company and battalion, or boat expeditions, the object of the essayist is to have the "division" as the basis of the organization. This effort is in the right direction. I think we will all agree to this: it is the decided tendency of the mind of the service. To apply this to battery drill, it is proposed to abolish the powder division as a separate organization, and to appoint men in each gun division to pass ammunition to their own guns. The assignment of men to a gun division is, of course, greater than is required to work the guns alone.

The division of force is made by setting off a certain number of men—petty officers, engineer's force, etc., as already assigned—and then arbitrarily dividing the remainder of the crew into equal divisions. Supposing the battery to be of such a character as to admit of this, the duties assigned to the navigator's division must also be made to provide the same number of men with occupation in action. I suppose this would be practicable by giving them some of the guns of the secondary battery.

Each division must be made up of similar material; petty officers, mechanics, cooks, and servants must be represented in each. This is specially the object to accommodate expeditions from the ship, that each company may find itself equipped for all parts of detached service. In serving the guns we shall find then the same class of men as now assigned to the duty of passing ammunition. They will be under the command of the officer commanding the division; this officer thus controls everything relating to his battery, including the supplies from the magazine and shell rooms. I think there is a good element in this proposition. The gun division is no longer dependent on another division controlled by separate authority: the officer of the gun division has in his own

hands the direction of every detail, and his responsibility is made more distinct. As a division officer I think I would like it: I would like to see the experiment tried. I recognize that there are men filling some stations who would not be attached to any division, as the gunner's mates in the magazines, the quarter-gunners at the shell rooms and armory, etc.; but this is a matter of detail that would be adjusted. It is the "runners" and shell passers who would have a distinct interest to subserve, each working for his own division, and competition would be introduced in a quarter where it has hitherto been unknown. These men would be exercised with their own gun division, and each one would become familiar with the character of the ammunition and the place where it is stowed—information which, under our present system, is limited to a very few men in the powder division, to whom the runners and shell passers look for guidance and direction. Breaking up this force of idlers into smaller bodies, separately instructed, will widen the scope of useful knowledge on matters relating to fighting needs, resulting in a more complete absorption of this force into the fighting organization of the ship. There can be no doubt that such training as these men will receive, under the proposed system, will make them more efficient as a reserved force when left on board to defend the ship during the absence in boats of a large contingent on distant expeditions. Their enforced familiarity with the gun division will fit them for doing good service with the battery.

I have said enough to show that I have been interested in the essay, and I do not know of any of the radical changes proposed that I would not be willing to subject to experiment, which, after all, must determine what our future organization is to be. I repeat that we are not yet familiar enough with our new ships and guns to lay down fixed rules for our future practice; the changes must grow with our experience. It is enough that thought is at work in this direction, and suggestions are in order. Our essayist has given much thought to the subject, and his suggestions are not only worthy of consideration, but many of them will, without doubt, be acted on. I think his paper is a valuable contribution to the literature of the Institute and to progress in the Navy.

NEWPORT BRANCH,

MAY 7, 1886.

Commander W. T. SAMPSON, U. S. N., in the Chair.

Captain A. R. YATES.—*Mr. Chairman and Gentlemen:*—There are some points I should like to mention regarding the retention of trained seamen in the Navy which are, I believe, of sufficient importance to be carefully considered in connection with the essay.

By reference to the new pay-table, it will be seen that the first-class petty officers of the seaman class receive about 50 per cent. less pay than those of the special

and artificer classes, although but one of each rate of the former class is allowed to any vessel, and there are of the latter classes sometimes two and more: as yeomen, ship's writers, schoolmasters of the special class, and machinists of the artificer class. No one can justly deny that the apprenticeship necessary to make a competent chief boatswain's mate, chief quartermaster, or chief gunner's mate is fully as long and difficult as that to make a machinist, and the qualities to be possessed by the former are rare and valuable. Further, these petty officers represent the seaman class, a calling essentially naval and seafaring, and the knowledge necessary to perform these requisite duties is obtained but at sea and in the Navy.

It is not surprising, with this fact of less pay, and consequently, in his opinion, less appreciation of the seaman class in the country before him, that the naval apprentice on completing his apprenticeship seeks a livelihood in other callings where more pay and greater comforts are obtained. He feels that he has been trained five or six years for a calling that can be followed but at sea and in the Navy, and the compensation he receives for this special knowledge is less than that received by those having a calling that can be followed afloat and ashore, and for which less preparation and knowledge is needed. While the pay of the special and artificer classes is not considered too much, it appears but just that that of the first-class petty officers of the seaman class, of whom there are but three in any ship, should be equal to it, and the pay of the other petty officers of this class, and the seamen themselves, should be more justly equalized with that of the other classes. It will not do to delay increasing the pay until there are competent men for these positions: inducements must be offered to make the apprentices render themselves proficient for these duties.

In this connection I would speak of the comforts of the enlisted men on board our war vessels. Wherein have they changed during the past fifty years? On the berth deck there are the traditional mess chest and jackstay. If men are allowed ditty boxes, or if their storm clothes and peajackets are stowed elsewhere than surreptitiously in nettings and forbidden places where they can be obtained without permission from the officer of the deck, it is owing to the consideration of the commanding or executive officer, and not to any regulation or provision made by the service or by the naval constructors, who, having never been to sea in a war vessel, are necessarily ignorant of many of the essential requirements for the comforts of the men. In fact, the encroachments of the officers' quarters, store-rooms, electrical plant, and ventilating apparatus, have left the hammock swinger barely the old regulation space of 14 inches—the same distance between hooks that was allowed in the old sailing ships when but one watch of hammocks was down at a time.

The essayist is correct in saying that thus far the numerical results of the present training system are not satisfactory. But it is believed that it is not so much the fault of the system as it is in the treatment the apprentice receives after he leaves the training ships, and the consequent poor encouragements offered him to remain in the service. In a country where the working classes are so generally well and comfortably housed, it is strange that in its naval

vessels the seamen have fewer comforts and conveniences than in those of the great European powers. It is to be hoped that in our new cruisers reasonable accommodations will be afforded the crew—not simply those in which they can exist, but those in which they can do so comfortably. Until this is done, no training system will be successful, for it will fail to retain the able seamen requisite for the efficient manning of the modern man-of-war.

Commander T. F. JEWELL.—*Mr. Chairman and Gentlemen:*—While approving in the main the recommendations of the essay, I am compelled to differ with the writer on several points. In the first place, I deprecate any interference with the training system. That system is now, after many years of effort, an organized system, and though the results are not as yet so satisfactory as we might wish for, I am certain that any curtailment would be a step backwards. The difficulty of obtaining efficient men in the service is not so much in the training system as in the retaining of the men after they have served their apprenticeship. As a matter of fact, the men so trained find that their training has qualified them for positions outside of the service more profitable than any they could hope to attain in the service. May not the real trouble be found by a comparison of the rates of pay of the several classes of enlisted men as given in the pay-table? By all means let us add to the number of efficient men in the service by enlisting and training young men in cruising ships, if it can be done; but does not experience tell us that this method will not give us the men we want? And I think you will agree with me that the man who is first of all a good, smart seaman is a handy man to have around for almost any kind of work.

I do not agree with the essayist in his suggestion that the numerical strength of the several divisions should be equal. As many men should be assigned to each division as are required to perform the duties of that division, and no more. The idea of the essayist seems to be that there should be the same close relationship between the men composing the division and the division officer as subsists between a captain and his company in the Army. I agree that a more direct and personal supervision of the men of the division by the division officers than now obtains as a rule, would be desirable; but that the number of men constituting a division should be determined by the desirability of giving each division officer a comfortable infantry company, I deny. Nor would I abolish the powder division as at present constituted. The present organization of the powder division makes available at general quarters and in action a large number of men who would not be available for service at the guns. To turn over the duties of this division to squads detailed from the gun divisions, away from the personal supervision of their division officers, would, in my opinion, be unwise. Let me add that a well-organized and thoroughly drilled powder division is not absolutely unknown in the service.

I am glad to see that the essayist lays so much stress on the necessity of better instruction in pointing and firing. It has always seemed to me that our practice in this respect was superficial and ineffective. Some method should be devised by which aiming and firing may be taught so that the instructor would be able to determine whether his men were profiting by the instruction.

I confess that I have never been able to satisfy myself on this point. A good shot at a target—as target practice is usually conducted—is as likely to be an accident as to be the result of proper instruction.

There is one point with regard to reorganization that I should have been glad to see touched upon in the essay. This is the era in which the armament of a vessel of war is of the most complex character, and in which expert knowledge is of the utmost importance. The high-powered ordnance, machine guns, auto-mobile torpedoes, dynamo-machines, electric-light circuits, both for search lights and for interior lighting, the care and use of gun-cotton and other high explosives, to say nothing of the application of electricity to the training, pointing, and firing of guns, will demand the services of a class of officers with much more advanced attainments than are possessed by a majority of the officers of the service at present. As it is now, it is usually a disadvantage to an officer to know much outside the most ordinary routine of his profession, for if he is found to be proficient in any other class of work, he has not only the routine work to do, but the other work as well. I should like to see attached to every vessel an ordnance officer whose principal duty should be the supervision and care of the armament of the vessel, but who might command a torpedo division, or give instruction in torpedo service to men detailed from other divisions, and who should be relieved from standing watch and from duty with gun divisions. If such a position is created, it should be filled only by officers who have the proper qualifications ; who have pursued a course of instruction in the Ordnance Shops at Washington, at the Proving Ground, and at the Torpedo Station.

The incentive to preparation for these duties would be the honor and distinction attached to the office. Mere lineal rank should not interfere with the assignment of officers to this duty, except that it should be confined to the grades below lieutenant-commander. The navigator, who is now the ordnance officer, if he properly performs the duties assigned to him as navigator, is already overburdened with work, and his rank alone is not a sufficient qualification for the position of ordnance officer.

THE CHAIRMAN.—The author in his introduction very properly attributes the promise of improvement in the character of our ships to the work of the successive advisory boards. To whomever may be due the idea of the Naval Advisory Board, to him we owe a debt of gratitude. The old plan of leaving the designs and interior arrangements of our ships to the Bureau of Construction resulted in constantly reproducing the same type of vessel, and doubtless would continue to furnish equally unsatisfactory results. Improvements would be adopted only after they had been elsewhere long in use, and even after they had been superseded by greater improvements, thus leaving us always a long way to the rear in the march of improvement.

Even if our constructing and engineering departments were always managed by men the most able in their profession, still it would be too much to expect them to keep pace with the changes in the many branches of science and in the art of naval warfare which are absolutely necessary to the proper designing of war ships. There is probably to-day no product of the hand of man which

embodies the application of more scientific and mechanical principles than a modern man-of-war. There is no more complicated machine, nor one which demands so much skill for its proper control and use.

This vastly increased complexity alone is sufficient reason why the constructor and engineer should, in designing new ships, call in the aid of those who must decide upon the armament and command the ship when she is completed. It is needless to say that, to command properly such a complicated machine, her construction and capabilities must be thoroughly understood, so that a double advantage is secured by associating the constructor, engineer, and military officer in producing the designs of our ships. We get, in the first place, more efficient ships, and those who are to command them acquire a knowledge of their capabilities of offense and defense which could not be so well acquired in any other way. From my limited experience in such matters, I am of opinion that in future our ships, and even our torpedo boats, should be designed by such a mixed board.

As a matter of naval policy, it would be, I think, a great advantage to the service, particularly at this time, when we are building up a new Navy from the beginning, if the Navy Department would prepare plans and specifications in anticipation of appropriations. Before Congress can make an appropriation with any degree of confidence, it must have the opinions of naval experts, or those who consider themselves such, as to the needs of the naval service in regard to ships. If an opinion is not forthcoming from the proper authority, there are always plenty of people in and out of the service who have their pet ideas of what a ship ought to be—too often one-sided—which are likely to be the basis for an appropriation for building ships. If, however, the Navy Department would submit the whole question of the increase of the Navy to a properly constituted board, and have designs prepared, so that when Congress is inclined to make an appropriation, perfectly definite information can be submitted for its guidance, such a course would create in the Congressional mind such a degree of confidence in the administration of naval affairs as, I venture to say, has never existed in this matter. To keep pace with the developments of naval science in other countries; to be prepared to take advantage of all progress made by them; to be ready to present to Congress, whenever it requires them or can be induced to increase the naval establishment, such plans as would, at the time, embrace the latest and most improved designs—all this would furnish continuous occupation for an advisory board.

Concerning the complement of a ship, I venture to suggest that the number of men and officers required to develop the full fighting capacity of the vessel should decide the question. A vessel of given displacement can mount a certain battery the character of which is determined according to some theory as to her future duties. If she is a cruiser, she would not be expected to contend with armored ships or forts; consequently the calibre of her guns should not be great. If she is to be a ram, she should have the heaviest practicable fire directly ahead, etc. Now, whatever may be the character or design of her armament, the crew assigned to her should be capable of developing her maximum power of offense and defense. Any increase beyond this point must detract

from her efficiency, because it must increase the weights, besides increasing the chance of casualties among the crew. The complement thus determined may or may not occupy all the berthing space in the ship. The same general rule should determine the number of officers. In this connection, it may be stated that for equal weights of armament the modern man-of-war requires a greater number of officers than vessels of older types, because the guns and their attachments are much more complicated than formerly. Each gun requires the close supervision of an officer, or, what comes to the same thing, the supervision of some man who thoroughly understands the use of the arm. When to this is added the complicated mechanism of torpedoes and search lights, and when we give proper weight to the fact that the movements of a modern man-of-war in action will be executed with the greatest celerity, it becomes evident that each part, combination of parts, and the whole ship must be supervised in the most rigid manner. For the same reasons, the education of our seamen must be vastly superior in some directions to what was required when sailing vessels and smooth-bores were the fighting tools. To go a little more into detail, it will be necessary to have an officer on board of each modern ship who shall be qualified to care for the batteries and torpedo outfits of the ship. He may be called the ordnance officer or the torpedo officer, but he should be appointed to the position because of his acquaintance with those weapons, and he should be responsible for the proper condition of them at all times. He should not have to stand a watch except at sea. These duties have heretofore been performed by the gunner under the general supervision of the navigator. This must be changed in our new ships if we wish to secure the maximum efficiency. The duty must have the exclusive attention of a trained officer.

We may say, then, in general terms, that the progress in naval architecture and high-power guns, with the greatly increased number of labor-saving devices applied in all parts of the ship, demands an increase in the number of officers, and a probable decrease in the number of men as compared with the same weight of battery of smooth-bores. When we have adopted some general scheme of this sort to determine the complement of the ship, all other duties to be performed must subordinate themselves to it. The engineer's force should be ample, and I am decidedly of the opinion that they should be instructed in their important duties; especially is such instruction necessary in the case of the firemen. We should not be annoyed by such variations in the speed of our ships under steam as are constantly occasioned by changing from one watch of firemen to another. The nicer adjustment of the capacity of boilers to the engines, and the use of forced draught, demand greater skill and care on the part of the firemen.

NORFOLK BRANCH.

MAY 26, 1886.

Captain GEO. BROWN, U. S. N., in the Chair.

The Secretary having read the essay, it was decided to discuss that part relating to the Marine Corps first.

Major JAMES FORNEY, U. S. M. C.—*Mr. Chairman and Gentlemen:*—I think that the best way to reorganize the marines would be to give them regimental formations, provided that the present strength of the Marine Corps, which is now only 2000 enlisted men, could be increased. Also, that three large depots should be established at Mare Island, Philadelphia, and Norfolk, where at least 500 men should be stationed, commanded by the requisite number of field and company officers. A summer camp of the same number of men would also be of great advantage.

The essay mentioned that the marines are not armed with the best rifles. I would state that they all have new rifles, calibre 45, No. of 1884. It has been demonstrated that officers are better adapted to command the guards of ships than non-commissioned officers. The paragraph in regard to there being only two officers in a squadron, and these should be graduates from Annapolis, is hardly feasible; for what use are the other officers to be put to? Besides, many of the civil appointments are equally as well educated, and as efficient officers as the graduates. Many of the generals of the Army are from civil life. The marine officers should be graduates from West Point rather than from Annapolis.

In connection with the marines working the guns on board ship, it has been the general custom for them to do so. I myself commanded a division of guns on the Brooklyn, Hartford, and Pensacola. I consider that it would be very injurious for the marine to lose *esprit du corps* as a soldier, and to make him more of a sailor than he really is now; for in the ordinary duties of a ship they pull and haul on the ropes and keep the regular watch; they protect public property, and all prisoners of war, that at times outnumber the crew; while ashore they guard and protect the navy yards, with their immense amount of public property, and are always ready for emergencies in adjunct cities, and frequently mobs in New York, Maryland, and other States have been quelled by the marines from the navy yards.

Lieutenant R. M. G. BROWN.—*Mr. Chairman and Gentlemen:*—I cannot agree with the essayist in regard to reducing the guards of our vessels of war. I would favor larger marine guards, and would have them drill at the great-guns and all rapid-firing guns. They should of course have the best magazine small-arms, and be our main dependence for landing expeditions. By having large guards, the ships of our important squadrons would be able to land 500 men—sufficient for all ordinary purposes. Another advantage of large guards, is that it would utilize the 2000 men in the Marine Corps, and allow of smaller complements of seamen. We would thus be enabled to keep more ships in commission; and what the Navy needs at present is more ships in commission.

First Lieutenant L. W. T. WALLER, U. S. M. C.—*Mr. Chairman and Gentlemen*:—I think the marines should be placed in charge of the machine guns on board of ships; and, if necessary to instruct them at the other guns, that they be drilled under the marine officers. In landing, the marines could act as infantry, and as light artillery with Gatling and 3-inch breech-loading rifles. A central depot should be established.* Details should be made from time to time for guarding navy yards. The depot should be made a school of instruction for officers and men; the use and care of rapid-firing, light and heavy guns, submarine mines, etc., to be a part of the instructions. Men should enlist for five years, and have regimental formation, and should be sent to sea under their own officers. The American marines are as capable as the English, and the system of marine artillery works well in that service. The corps should be increased by 500 additional men.

Commander P. H. COOPER.—*Mr. Chairman and Gentlemen*:—I do not infer from my reading of the essay that the author intends to criticise the efficiency and value of the marines. His idea looks towards the manning of our future ships with a homogeneous body of men, if possible. Special training being needed for the secondary batteries, and there being no place on board ship for any but a force that will fight the ship, no room for a body trained especially as the nucleus of a landing party, it seems to me that the essayist on this ground minimizes the marine guards.

Granted, however, that the marines can receive preliminary drills and instructions with machine and rapid-firing guns, fitting them to be a body of marine artillerists, I have no doubt that the universal opinion would be that no more valuable and reliable adjunct to the fighting complement of the ship could be had.

THE CHAIRMAN.—During the war the marines were given great-guns to serve and were commanded by their own officers; they served those guns as well as the blue-jackets; and there is no reason why the marines should not be instructed on shore in the use of machine guns and on board ship at modern great-guns and carriages. When it becomes necessary to land a small force from a single ship, or a larger force from a squadron, the marines are better prepared, from previous training, to perform duty on shore than the blue-jackets.

There should, in my opinion, be a marine officer in every ship having a guard, so that in the event of the whole force of marines being landed, there would be enough officers to organize properly one or more companies. I have never known a commanding officer to complain of having too many marines under his command.

The Secretary then read that part of the essay relating to the training system.

Lieutenant BROWN.—*Mr. Chairman and Gentlemen*:—I consider the training system a great benefit to the service, and would regret to see the system

* Craney Island, Va., is a central position, and would be good on account of the climate.

crippled. The supposition of the essayist that only a few return to the service is no reason for abolishing the system. If only ten per cent. return, I should advocate the system. The apprentices have to serve until twenty-one, and there are several hundred now serving on regular men-of-war after having completed a course on the training ships.

It is a question whether the unpopularity of the service is not greatly due to the constant drilling necessary in order to make a sailor "jack-of-all-trades." It is certainly desirable to retain the best graduates from the training ships in the service. To do this, the service must be made more attractive. We should remember that sailors, like all laboring men, are chiefly influenced by the relation between the hours of work required and the pay earned.

I think it is generally complained of by the officers of the training ships that the petty officers of the ships are not graduates from the training school. Many of the petty officers of these ships are men whose characters are bad. If the best graduates were retained as petty officers, it would remedy this evil.

Captain Geo. C. Remey.—*Mr. Chairman and Gentlemen:*—I think the present apprentice system should be continued, but modified from time to time in its formal administration as experience may prove advisable. After serving a length of time, say six months or a year, if it be apparent that an apprentice has no aptitude for the service, he should be discharged in a home port. I would also adopt the plan of enlisting men under twenty-five years for general service. These men should also be liable to discharge at the end of six months, if found unfit for service. With the exception of the recommendation of the essayist to put the present training system on a reduced basis, I agree mainly with his views, and feel that he is entitled to the thanks of the service for his vigorous essay.

Lieutenant-Commander E. S. Houston.—*Mr. Chairman and Gentlemen:*—I am of the opinion that the present system should be continued, notwithstanding the somewhat discouraging showing of actual numbers permanently added to the service. This result comes from a state of affairs peculiar to the present conditions of American life—conditions which will gradually change for the better in the future; and while the service may not now get such benefit for the outlay, it undoubtedly will in the end and during a war. Keeping this in view, I favor not only its continuance, but its expansion by Congress as a wise national policy. Regarding its internal management, I think we may safely leave that in the hands of those having it in charge, as in this, as with most questions connected with the service, it is not the want of wise measures so much as it is the lack of means to carry them into effect.

Lieutenant-Commander Marthon. — *Mr. Chairman and Gentlemen:* — In my opinion the training squadron should be continued, even enlarged. The small per cent. of re-enlistments does not by any means remove these trained men from a seafaring life. A large number of them ship in the merchant service, where they are able to reach the positions of mates. Others will, after a time, return to the naval service. Others, though giving up sea life, are always available in time of war to man our coast and harbor vessels.

The system in my opinion turns out able, intelligent, sober, and healthy men, and a more reliable class than those men who are picked up at home or abroad, and who, being only desirous of a living and good pay for a short time, soon leave the service and country forever. The greater part of our crews on foreign stations are of this nature, really "birds of passage," without character and, I might say, without country. The apprentices are all Americans, and extremely loyal to their flag. Therefore, in my opinion, the system should be continued. The petty officers of the training squadrons should be taken from the ablest of the graduates, as suggested by Lieutenant Brown, not only as an encouragement, but as a just reward for their merits.

These boys on cruising vessels I think are better informed in regard to great-guns, shells, small-arms, infantry, and battalion drills than any of the old men on board. This very great advantage of knowing the internal rules and stations of a man-of-war, when a number of them are transferred to a vessel, saves men and officers a vast deal of trouble in the beginning of a cruise, as well as when on a foreign station. The naval education which they receive during their apprenticeship makes them good, reliable citizens, with a greater knowledge of what the outside world is like, and a stronger love for their own country, which they will be ever ready to defend in case of need.

THE CHAIRMAN.—While it is desirable to have apprentices re-enlist and remain in the service after reaching their majority, the fact that only a small percentage do continue in the service is no evidence that the present system is a failure. The early training of a boy on board the training ships and in cruising vessels will never be forgotten by the man, and although he may find a more agreeable occupation on shore, we can rely on obtaining his service in time of war, and therefore the cost of his training is not thrown away. In civil life, the man who has had three or four years of discipline and training in the service as an apprentice will be a better and a more useful citizen in the community in which he resides, and the Government will not have thrown away the money expended in his education.

U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

HONORABLY MENTIONED.

MOTTO:

The result of all naval administration and effort finds its expression in good organization and thorough drill on board of suitable ships.

WHAT CHANGES IN ORGANIZATION AND DRILL ARE NECESSARY TO SAIL AND FIGHT MOST EFFECTIVELY OUR WAR SHIPS OF THE LATEST TYPE?

BY ENSIGN W. L. RODGERS, U. S. N.

Organization and drill in the Navy depend on the laws for the Navy and the customs of the service. Customs being flexible, we naturally find them conforming to the needs of the service almost as closely as the laws will permit, and, therefore, without legislation we may not hope for any decided improvement.

The production of efficient men-of-war being the sole object of a navy, it is apparent that the Navy Department as headquarters, and its organization, demand the first consideration.

The present system of departmental organization and administration began in 1842, when the Board of Navy Commissioners was abolished. At that date the modern changes in naval science had just begun with the tentative introduction of steam on board the Princeton, but the great revolution in the near future was unforeseen, and the new organization, while good, was only equal to dealing with the existing problems. Since that time our native-born seafaring population has disappeared, and all naval science has made the most wonderful progress. To meet these great and varied changes and the greatly increased duties entailed by them, the bureaus of the Navy Department have been multiplied, and the individual bureaus have added function to function; but they have grown only by accretion: never

in these forty years has there been a general survey of the field of naval affairs and a corresponding change in the organization and distribution of duties in the Navy Department.* As a result, each bureau has endeavored to become independent of all the others, relying entirely upon its own resources, and caring little for the demands and necessities of the others, while it has gathered to itself the most incongruous duties, and cares only for the fitting out of ships. After ships are commissioned, there is no one in the department who is interested in their efficiency.

If we turn to the reflection of the bureau system on board ship, we find the bureaus each represented there by an officer charged with the duties and stores of the corresponding bureau, and with certain men more or less under his control; he is subject only to the captain and not to the executive officer; so that there is one system of control for the majority of the officers and men, and several systems for the minority.

The direction and supervision of drills and of discipline, as well as other executive functions, are distributed among the various bureaus, instead of being under one; and as bureaus are organized and fitted for office-work, they exercise their control only by means of quarterly returns, so that if commanding officers are careful about red tape, they may carry out drills or obey circular orders very much at their own discretion.

The duties of the Navy Department are twofold. First are the civil duties, including the building and maintenance of ships and navy yards, and the manufacture and purchase of equipments and stores; then there are the military duties, which embrace the recruitment, discipline, instruction, and drill of the officers and men of the Navy, both ashore and afloat, the control of the movements of all vessels, and the direction of fleet operations. These two classes of business have nothing in common, and should be entirely distinct from each other, with a "director of construction" at the head of the first, and a "chief of staff" over the other. The bureaus should be retained as administrative units, but altogether under the authority of the "director" and "chief of staff," and with a redistribution of duties, so that all those of any one bureau would be naturally related. Under the "director of construction" should be the bureaus of supplies, of construction and engineering, of ordnance, and of yards and docks. The first bureau should be charged with the purchase and care of

* The above was written before the appearance of the Secretary's report.

all stores, materials, and supplies for use in navy yards and in the fleet, and should issue them upon requisition. Under the "chief of staff" should be all the military duties before mentioned, and in addition the records of officers and men, details, issue of general orders, circulars and drill manuals, inspection duties of all kinds, and the Office of Naval Intelligence. Inspection duties are among the most important in all well-managed military organizations, and are on a very inefficient footing in our Navy. The officers detailed for inspection should be the eyes and ears of the Department in the service at large. All records and work in the yards, and the entire economy of ships, should always be open to their examination; and besides reporting upon the condition of what they see, they should be expected to suggest improvements wherever called for, thus acting as a spur to the rest of the Navy. These officers should compose all boards for the examination of technical matters. The Secretary would thus be left the general control of the Navy unembarrassed by technical details, retaining as his special province the relations with the President and Congress, and the complete control of all financial matters. The Secretary has recently taken steps to bring the finances more under his own control, and the result will doubtless be most excellent.

As the Secretary is allowed by law to distribute the work of the Department among the bureaus, there would be little difficulty in making any arrangement that he pleases, were it not that the bureaus and the corps of their chiefs are defined by law, and that the annual appropriations are made for each bureau separately. He has, however, very wide discretion and authority in the matter.

The Corps of Officers.

Now to consider the officers of the Navy. In intelligence and natural abilities, they compare very favorably with those of other nations, but they are heavily handicapped in many respects. The young officer upon graduation finds himself at the foot of the long ladder of promotion, with the certainty that no good conduct or professional ability will advance him out of his turn, and with the equal certainty that nothing but the grossest misconduct can retard him. The general opinion of his brother officers is not of importance to him, for they cannot reward or punish him; the examinations that he passes are mere repetitions of those at graduation; and so he goes

on to the highest grades of the service, relying more on physical than on professional and moral qualities, and with only the satisfaction of duty well performed as an incentive to faithfulness and zeal. There are many officers in the service who are fully equal to the duties of subordinate grades, yet who have not the ability to fill the higher grades with credit. It is desirable to retain these men in the service, yet there is no reason why the Government should place them in situations whose requirements are beyond them. In every other walk in life a man's success is proportioned to his ability, but in the Navy the rigid system of promotion results in a frequent lack of cheerfulness and exactitude in obeying routine orders and carrying out routine duties; this becomes apparent even to civilians in the careless mode of wearing the uniform.

There was submitted to the last Congress a system of promotion which permitted undesirable officers to be retired on reaching the rank of commander or captain. This plan, combined with a rigid system of progressive examinations, would be of benefit to the service, but the system in practice by foreign nations is preferable. There we find that a large number of promotions take place by seniority, but the government reserves to itself the right to select specially promising officers and promote them out of their turn. Those chosen are usually not advanced very much at a time; must pass rigid examinations, and have certain records of conduct and service, so that none but deserving men are advanced, while those remaining in the lower ranks are retired by age limitations. In this way, as in civil life, a prize is held out for zeal, good conduct, and ability, and the country gets the benefit of capable service.

There are two arguments advanced against this scheme. However the sustainers of the first objection may present it, it amounts to this: "If such a scheme becomes law, A. B. will be promoted over us." In most cases the obvious answer is that such a result would be very desirable. But many officers, while acknowledging the advantages of such a plan, doubt whether it could be put in practice and carried out with substantial justice. The general opinion of the service, together with examinations, would probably be weighty enough to prevent the selection of unworthy or undeserving candidates; this is as far as justice can go, and is all that is desirable in this case. What is necessary is the assurance that officers shall rise in some degree according to their merit, so that men of inferior ability shall retire early in the lower ranks by age limitation, while better men rise

proportionately higher. The present system, however, may be called unjust, for now rank is no measure of ability and merit; the proposed system tends to make it so in a general and limited way. Much improvement can be accomplished in this direction without legislation. The primary duty of every officer in the Navy is on board a seagoing ship, but this is not recognized in any official way by the Department, and shore stations are naturally preferred. Officers are now sent to sea by the roster, and no matter what their qualities for command may be, they are sure of getting vessels. Before the war the *personnel* of the Navy was in very much the same condition that it now is, and as a remedy the Department adopted the policy of entrusting ships only to the best men, allowing those who were not fit for sea duty to remain on shore. This was an expensive method of manning the fleet, but it set a premium on professional merit, and procured the best men by giving to officers of all grades higher commands than their rank entitled them to hold.

A reason why incompetent officers so readily pass their examinations is that, although ample data for rejecting them exist in the Department, it is very hard to collect it in any given case; and when officers are questioned regarding candidates for promotion, their good nature sometimes permits them to give official answers very different from their freely expressed real opinions. The remedy is to keep an index in which to enter under each officer's name every article of information and official reference regarding him as it comes into the Department. Moreover, it sometimes happens that newspapers make scandalous charges against officers of which no notice is taken, because it is no one's business to do so. It should be the duty of the Judge Advocate-General to investigate such charges without further notice, and deny them in the name of the Department, for the credit of the service, if they be false, or bring the offenders to trial if they be true.

A post-graduate school, where officers may practise the latest novelties in naval science and perfect themselves in the theory of the various specialties, is an absolute necessity. The study of the higher branches of the profession should be deferred until after several years at sea, when it would be more profitable than under the present system; for it is only from the careful study on shore of the experience gained at sea that improvement is derived. For such a school there can be no place so fit as Annapolis, which already possesses all the advantages of a complete and well-organized educational establishment.

The primary duty of every naval officer is to handle and fight his ship well, and, in the organization of the Navy, combatant efficiency should be the sole consideration. Incidentally we find officers and men performing divers auxiliary duties in time of peace, but this is merely to utilize their abilities, and should be considered as of no weight in influencing the organization of the service. Naval officers are rather arbitrarily divided into two classes, the line and the staff, staff officers being assumed to be non-combatants, and friction arises between the two classes from the false position in which the engineer corps is placed. This corps, of later origin than the other staff corps, has become of great, though not fully recognized, importance, and has received an education beyond the position that it holds; and while chafing under this state of affairs, it has found some support from the other staff corps.

In examining the present status of engineers, we find that they have every official and social recognition except that of military command, when the truth is that they are combatants in every sense of the word, and should be recognized as such. The education of engineers is a most thorough one, embracing designing and building engines, as well as the practical duties of the engine room. But the primary duties of all naval officers are on board their ships, and therefore, when engineers are assigned to designing duties, they are not as efficient as those who do nothing else. At sea, however, our engineers, being conscious of education and attainments above the duties there assigned them, have introduced machinists on board ship. So we have a poor class of machinists, because they are not responsible nor trusted, and the engineers complain that they are unreliable when placed in charge of the engine-room watch. It is not sufficiently recognized that every man-of-war is one homogeneous machine, and that, therefore, all officers on board should belong to one corps, all finally rising to command and acquainted with all the duties called for on shipboard, but each devoting himself to the study of one of the various specialties of his profession. The present system of special corps leads to the absurd conclusion that if a lieutenant and engineer go out in a torpedo boat and either is disabled, the survivor can do nothing but surrender.

The law of August 5, 1882, was a step towards the solution of this question, in making all cadets follow the same course at Annapolis and choose their corps after two years at sea. To complete the solution, the engineer corps should be abolished by absorbing all the

assistant engineers and as many as possible of the passed assistants in the line, leaving the rest to perform their present duties until retired. Such an increase of subordinate officers would be an additional reason for promotion by selection, in order to prevent officers from passing through the upper grades of the service in a very few years. By this plan the engineer division would be placed under one or more combatant officers, who would have charge of the machinery and engineer force. Engine-room watch and the immediate charge of engine-room work would then fall on a trustworthy class of machinists similar to locomotive engineers, who would be attracted by the increased responsibility and by a well-defined position with light work. There is no occasion on board ship for the designing and constructing talents of the engineer corps, because large shops are needed as a field for them, and if a ship is so badly injured as to need anything more than a temporary makeshift, she must always go into port. All this part of the present duties of the engineer corps—namely, engine-building—should be performed by a small corps of constructors, who should never go to sea, but be always employed on shore. This corps should design and build the hulls as well as the machinery, and as naval construction is different from ordinary ship-building and requires special training, this corps has every claim to a place on the Navy Register.

As for the paymasters, their duties consist in caring for and issuing the stores of the Bureau of Provisions and Clothing, and in acting as treasurer and accountant for the ship and crew. Here is nothing that any careful, honest man cannot do with the ample time at his disposal on shipboard. Indeed, the Navy Regulations provide that line officers may act as paymasters upon occasion. Additions to the pay corps should therefore be stopped, and all its duties be performed by line officers. The object gained would be the substitution of combatant officers for a corps of non-combatants, who do not add to the fighting efficiency of the service. Chaplains should be commissioned for each cruise, not permanently. With regard to the other corps borne on the Navy Register (surgeons excepted), as they do not go to sea, and may be recruited from civil life in any number and at any time, there is no reason why they should appear as naval officers enjoying privileges which are granted to officers as inducements to sever their relations with civil life. After careful consideration, the plan of having only one corps in the Navy does not seem to ask for too much from individuals, for it does not require officers to

be perfect in all branches. It is the system which was adopted by the Indian Army when the conclusion of the Sepoy mutiny called for a complete reorganization. There the cavalry, infantry, and staff officers all belong to one corps called the General Staff, and officers are detailed to various duties for a term of years, any one being liable to serve in diplomatic, civil, military, and engineering capacities, according to his abilities and the needs of the service. In the European armies, too, the best officers are required to serve in other corps than their own.

The chief difficulty in the proposed change would arise from the consolidation of the line and engineers, but it would not prove a substantial one. Line officers now know little about engineers' duties, because they have nothing to do with them until they reach command, but with the proposed change there would soon be a class of young officers giving special attention to the engines and equal to all their duties in that line. Indeed, at the present time, naval cadets only a few months from Annapolis, and ensigns, are frequently trusted with the charge of the engines under way, and perform all their duties both on deck and below with credit. This change would not prevent the development of specialties, for on board ship a man has not great opportunities for study: his duty there is to train and educate his men and obtain a practical knowledge of his profession. The specialist on board ship, who cannot go beyond his specialty, takes the place of a better man. On shore, however, in the various fields of work now occupied by officers of the Navy, there would be abundant opportunity for the study of the profession and the development of specialties, and every one should be encouraged to follow his taste in this matter.

The Corps of Enlisted Men.

The class of enlisted men now serving in the Navy is far from a satisfactory one. There are many foreigners, who ship because they can send money home periodically. The country could not expect their service in time of war; some of them can barely speak English, and most of them care nothing for the flag and take no interest in the efficiency of the ship. Then the term of service is so short that a ship cannot make a three-years' cruise without renewing the greater part of her crew, to the great detriment of efficiency. Finally, such is the anxiety to obtain men that enlistments are permitted and even

desired on board seagoing ships, where recruits frequently receive no proper training, but are put at their stations a day or two after shipping, and sometimes learn their duties by natural intelligence, but more frequently at the expense of the other men's drill and efficiency. The enlistments which are made abroad are of a very poor class, for they are usually of foreigners, or of worthless Americans who make use of the Navy as a temporary convenience, with the intention of early desertion. The Marine Corps compares most favorably with the Navy in these respects: the long term of enlistment enables a guard to make a three-years' cruise without many changes and to join the ship in an efficient condition, and the habit of forbidding all enlistments on shipboard raises the standard of recruits. With regard to petty officers, there is no such class in the Navy. To be sure, there are men holding the ratings, but they know nothing but seamanship, and not always that; are without authority, and command no respect.

To supply all deficiencies in our enlisted men, we should adopt the English system of recruiting and manning the Navy. We can draw few hints regarding this matter from other European navies, because they depend on compulsory service; but England relies on voluntary service, and with similar laws, customs, and naval usage to ours, her system is perfectly adapted to this country, and by adopting it we would find ourselves in possession of a practical method which has given England, though with her merchant service largely manned by foreigners, a navy manned by sober, self-respecting, native-born Englishmen, of sufficient intelligence and education to perform their duties well and furnish out of their number a class of reliable petty officers who are thoroughly respected and obeyed by the crew. The English system enlists boys at about sixteen years of age, before they settle down to trades, and, after a preliminary training, they serve twenty years in two enlistments, counting time from the age of eighteen. Those serving out both enlistments have pensions proportional to their latest pay while in active service. It is noticeable that of late years the question of State responsibility for the employment of honorably discharged soldiers and sailors has been much agitated in England. The men have given the best years of their lives to the Government, and in so doing have sacrificed their local connections, making it difficult for them to find employment upon discharge, although their general intelligence and habits of discipline render them particularly well suited for many positions. Under these cir-

cumstances, it is urged that the Government owes it to them to make some endeavor either to provide work for them, or by recommendations to obtain them work elsewhere. At the same time it is fully recognized that they cannot be allowed to exclude others from employment, as that would inevitably result in poor work and consequent failure of the plan.

In our service the pecuniary position of enlisted men is a hard one, and keeps away many good men in not allowing them to receive their pay except as the captain permits. There is no reason why men's pay should not be as completely at their disposal as that of officers. The present system of wages also is bad in that the pay of each rate is fixed, with a dollar a month increase for each re-enlistment. As the number of men of each rate is fixed for each ship, this plan does not offer sufficient inducement to good behavior and zeal. A better system would be to offer a small fixed pay of about ten dollars a month, with a series of supplements for proficiency in ship's work and in each of the various drills, with large supplements for good conduct. This would be a direct incentive to effort in any direction. The maximum supplement for any branch should be such as to make the desired number take it up. The lower grades of supplements should be readily obtained, but as a man's proficiency increases he should find it harder to obtain the next greater supplement. The supplement for good conduct should not be affected by petty offenses, but, once reduced, it should be hard to increase it again. Petty officers should receive an additional supplement proportional to the responsibilities they incur and the duties they actually perform.

A few words may be said here of warrant officers. They occupy a somewhat anomalous position in the service, for vessels without them do not feel the lack of them. In fact, it is apparent that the only use of the corps is to afford an opportunity of promoting deserving petty officers, and it is unnecessary to enlarge upon the poor economy of maintaining a body of men who are of no direct service to the country. The proper thing to do for the petty officers is to improve their position as such. At the same time, it must be recognized that promotion can never be closed against real merit, and that there must always be admission to the corps of officers for those seamen who deserve it. They can never be numerous, for the advantages of a fine education are necessary to make good officers, and few enlisted men could ever merit commissions. Even those obtaining them would retire early by age limitations, except in the rarest instances.

Organization of Officers on Board Ship.

We now have to consider organization on board ship; and first, of the officers.

There should be only one officers' mess, as in the Army, where the plan works well. By this means a number of non-combatants as officers' servants would be saved, the mess expenses would be lighter, the larger size of the mess would render it easier to maintain that general good feeling which is sometimes lost towards the end of a long cruise, the younger officers would benefit by association with their elders; finally, it would be easier to perform those social duties which are now frequently neglected. The captain should belong to the wardroom mess, thus saving a cook and steward, but should dine in his cabin.

As was explained before, all the officers of a ship except surgeons should be combatants, ready to perform any service that may be required on board. The captain should assign each officer to his division, consulting his wishes if possible, and no officer should be permitted to change his division during the cruise. In case of a vacancy occurring, the relief officer should take the vacant division without regard to seniority. The authority and responsibility of all divisional officers should be increased. They should keep the accounts of their divisions and prepare all requisitions, clothing and small-store bills, thus performing much of the work which now falls on the paymaster. They should be consulted about the rating and assignment of petty officers to their respective divisions, and should have control of their men's privileges, subject to the captain and executive officer. Whenever a man is brought to the mast, his divisional officer should be present as his counsel, to call attention to his previous record, or help him in any other way possible. In general, men should go to their divisional officers where they now go to the executive officer. This would in no way diminish the latter's authority, but, by associating the divisions more closely with their lieutenants, it would increase his control over both the officers and crew to the benefit of the service.

Having considered the generalities of officers' organization on board ship, we must now turn to particulars. The captain must naturally remain, as he always has been, responsible for all, and the soul of the ship in time of action. The executive officer should be responsible to the captain for all; his special charge should be the

care of the ship, of all stores for the ship's use, and of the discipline and organization of the crew. His station in action should not be in the fighting tower with the captain, as there would be a great probability of losing both together. If there should be a second fighting tower, the executive officer might occupy that; otherwise, he should be at liberty to go where his services may be required. He should command all expeditions out of the ship.

The navigator should have charge of all navigating, meteorological and surveying instruments and all charts, and should perform those duties of the paymaster which are not assumed by the divisional officers, as well as all navigating and hydrographic duties. In action he should be the captain's aide, navigating the ship when on soundings and attending to signals. He should have charge of all stores for the use of the crew, and should act as (army) quartermaster in all expeditions out of the ship. As his duties would not keep him in touch with the crew, some of the divisional officers should be his seniors, to prevent his replacing the executive officer. The present navigator's division should have a watch officer in command, who should have charge of the machine guns of the upper deck, and the fire from the tops. He should also look out for the torpedo netting and handle the electric lights in action. It is doubtful if one man could efficiently control the entire machine-gun battery even in small ships, but in large vessels it would certainly be necessary to make two divisions of it. The duties of the officers of the gun and powder divisions should not differ materially from the present practice. There should be a torpedo officer in charge of all the torpedoes and mines of the ship. He should command the torpedo division, and his station in action should be with the bow torpedoes. The junior officer of the torpedo division should command the torpedo boat of the ship. The torpedo officer should lay and fire all mines and countermines, and should be in charge of electrical machinery and gear. He should not belong to the landing party. One of the divisional officers should be the gunnery officer charged with the care and maintenance of all arms and ammunition, and he should not be in the landing party. Finally, the engines should be in charge of one or two officers responsible for the efficiency of the engines and that of the engine-room force, but not standing engine-room watch, nor undertaking the immediate supervision of work; these duties should be left to petty officers. Officers should be induced to qualify for the various special duties just enumerated by the offer of a permanent

supplement for the mere fact of qualification in any branch. An additional supplement should be granted during the actual performance of the special duty. Officers should stand watch at sea as they now do, but in port the charge of work should be committed as far as possible to petty officers. The divisional officers should stand day's duty, being responsible for work going on, but with time to attend to their special duties.

Organization of Enlisted Men on Shipboard.

The organization of the crews of our men-of-war should begin on shore in the navy yards, which, besides being supply and repairing depots, should be training stations for the men. There should be ample drill grounds and barracks, and here the boys from the training squadron, and the men returning from three months' leave after a cruise, should be sent to await orders to seagoing ships. It is a great mistake to keep receiving-ships. It is impossible to form seamen by merely teaching men to sleep in hammocks, and every other imaginable advantage is on the side of the barracks. The men should be organized on somewhat the same system as that at Annapolis, which affords the most favorable opportunities for division into classes, for instruction, drill and discipline, and renders it comparatively easy to deal even with recruits. There should be a large number of officers at the barracks in charge of the men, and there should be an effort to arrange details so as to send one or more officers from the barracks to the same ship with every detail of men, in order to maintain as far as possible the same method of drill both ashore and afloat.

In considering the position of petty officers, every one agrees that the old class of men is insufficient, and that to obtain desirable men more pay and more privileges must be offered. But pay, privileges, and comforts do not appeal with enough force to the intelligent and self-respecting class that is necessary, and the great inducements of increased trust and responsibility must be added. In fact, it is not too much to say that there is now no class of petty officers in the Navy, and that there can be no good organization without such a class. Those holding the ratings are simply leading seamen, drawing higher pay, but without the superior instruction, the security of tenure, the authority, and the respect for their own positions, which are necessary in every well-organized military body. Improvement

in petty officers can only be effected by marking them off as distinct from and superior to their shipmates, as is done with non-commissioned officers in the Marine Corps. The lines necessary to effect this can best be established in barracks, where the men who have served as petty officers should be rated as such and opportunities should be afforded for others to qualify; those under probation being rated as vacancies occur. The petty officers should be given a separate mess and quarters, as many privileges as possible, and should receive special instruction in their various duties. The charge of discipline and police duties and the instruction and drill of the force in barracks should be committed, as far as possible, to petty officers, and although they should be watched by the staff of officers, and instructed and counseled in the way of exercising command, yet they should always be made to feel that they are trusted and responsible for the performance of all work assigned to them. It is scarcely necessary to say that it is impossible to commit all drill and instruction to the petty officers, and that the officers must always make their control and initiative felt, and take direct charge of all bodies of men larger than a small squad. There is at present a class of petty officers—of whom quarter gunners are an example—who perform duties which require intelligence and reliability, but who exercise no military command; such men deserve high pay, but they should not form part of the body of petty officers described above. It is in this way, and with the advantages of a long term of enlistment, that marine officers have succeeded in forming a corps of men which is superior to that of the blue-jackets, and a class of non-commissioned officers who retain their authority and the respect of their subordinates throughout the trying circumstances of a long cruise.

On transferring a body of men to a ship about to be commissioned, it is necessary to organize them according to the bills. There are two classes of station bills: to one belong all the fighting bills, to the other belong all for handling the ship and carrying out routine work. The principle that should govern all the fighting bills is that, no matter how or when the men are brought into action, they should always find themselves under the same officers and petty officers. The working bills should be regarded merely as permanent details from the fighting bills, in order to distribute the work equally among all, and to prevent loss in battle from disturbing the routine of work. To accomplish this, the basis of all organization should be the quarter bill. The records and various qualifications of the men should be carefully

examined, after which they should be fairly distributed among the divisions, assigning a good marksman qualified in the gunnery branch to every gun. The qualified torpedo men should go to the torpedo room and the torpedo boats, the qualified mechanics and firemen to the engine room, and marksmen to the tops and other small-arms stations. The rest of the crew, of various degrees of training, should be assigned as necessity requires. The powder division will require great attention to ensure the prompt supply of small-arm ammunition to the tops and the sure delivery of the various calibres of machine-gun ammunition. Indeed, it is very probable that constructive changes in the vessels may be found necessary in order to obviate delay and mistakes. Every man should be assigned to the station which he is most capable of filling, and no changes should be made without a real necessity. It is quite wrong to shift men about merely to preserve an ideal symmetry in the station bills. The efforts of the captain and executive officer should be to encourage divisional *esprit de corps* and cause each officer and his division to feel that they belong to each other and must work together.

As it is proper for the crew to go to quarters upon any emergency, it is evident that the fire bill must be based upon the quarter bill, as it now is.

The next bill to make out should be the watch bill. It should have much the same relation to the quarter bill that it now has, so that losses in one division may be distributed to all parts of the ship; but both watches should be drawn equally from every gun's crew, as is now the case with pivot guns. The ease of handling the new guns will permit this without causing delay in opening fire.

The next bill made out should be the battalion bill. The force of the landing party for each class of ships should be prescribed in the Ordnance Manual, also the mode of armament and equipment and the numbers of pioneers and other auxiliaries. In uniting the forces of several ships, it would usually be advisable to change the equipments of some of the auxiliaries, or the kind of guns, or even to leave part of the artillery behind. Therefore, the proper proportion of guns and auxiliaries for each increase in the total force of an expedition should also be laid down in the Manual, and under each total the proper equipment for the first, second, and third ships participating. Each ship, having received a squadron number, would then know what force to send.

In organizing the battalion, each division should furnish a complete

company under an officer of that division. If it should sometimes be necessary to form a company with men of two divisions in order to have it of full size, the two divisions should be represented by the platoons, each with its own officer. With modern guns, the guns' crews are usually large enough to work with half crews, and therefore the second half of all guns' crews should furnish the infantry. Care should be taken to have the best small-arms marksmen and most active men in the landing party. The riflemen belonging to the tops should be men not so good at marching, and should be left on board for the protection of the ship. Some of the machine guns, each with its complete crew, and details from the rest of the machine-gun division, should form the artillery. The pioneers and mechanics should come from the engineer's division, and the special details for the care of stores, for stretchermen and other duties, should come from the powder division. This division might be able to furnish a company of infantry, but if possible it should keep nearly its full strength on board, in order to enable the half crews remaining on board to maintain a brisk fire, in case of an attack during the absence of the battalion.

The boat bills come next. There should be two of them. The first one should be similar to the battalion bill, so that on arming, each company or platoon would remain a unit and form the crew of a boat. Coxswains should all belong to the battalion and to their own boats. The second boat bill should be the "abandon-ship" bill, and should contain the names of all on board; each boat containing its fair proportion of mechanics, seamen, idlers, etc. Some of these men would be permanently excused from boat duty; the rest should form the boat's crew, the coxswain detailing the crew for each day precisely as the captain of a part of the ship now makes his details. There should be no boat officers: coxswains should be held responsible for the conduct of their crews.

In the organization of the engine-room and fire-room force, those men should be assigned there who are in receipt of the supplements for duty in that division. This should not prevent them from obtaining some of the lower supplements for gunnery and target practice; and, *vice versa*, the men of the deck divisions would be better for some elementary knowledge of steam. We may see this exemplified every day in the steam launches when the coxswain starts the engines or the fireman finds it convenient to bring the boat to the gangway; and, with the isolation attendant on the modern sub-

division of ships, the diffusion of such knowledge becomes essential. It also seems as if the present multiplicity of independent engines on shipboard, far from rendering necessary the employment of highly educated scientific engineers to take charge of them, affords precisely the opportunity for such an organization as has been indicated, where the engine-room watch is committed to well-trained petty officers.

The mess bill must always depend on the watch bill; but as long as the present system of messing is retained, it should also depend on the battalion bill, so as to send ashore complete messes without disorganizing those that remain. This could be accomplished by making the second parts of the guns' crews of any one division (which form a company) belong to the same watch, and mess together. It would be equally easy to place the field artillery in one mess. The present system of messing should no longer be retained, for it is little better than barbarous, and of itself is sufficient to forbid the enlistment of a desirable class of men; especially when the training ships are so much better in this respect. It is wasteful of provisions, unfavorable to good cooking, and keeps an encumbered and close-smelling berth deck, besides requiring a large number of mess cooks, who are usually dirty foreigners wanting the extra ration, whom the executive is ashamed to have about the decks, whose time is not half occupied, yet who avail themselves of their mess duties to avoid their deck work. There should be a ship's pantry on every ship, and the ship's cook should have a small number of assistants—enough to do all the cooking and take entire charge of the pantry, with its mess gear, and do all the washing of dishes, etc. The berth-deck sweepers should set the tables and draw and return the mess gear. Some of the cooks should be attached to the landing force, and on landing every man should carry his own mess gear, as at present. The petty officers' mess should be rather better than the others, with china service, and permission to use mess money. The other messes should all be on the same footing, without mess money. The savings in the ration, owing to the decrease of waste, would be very considerable, and the commutation, with the improvement in cooking, would furnish a very good table.

There should be a meal between 7 and 8 P. M., for it seems to be shown that the desire for liquor when on liberty is decreased when the length of the fast between supper and breakfast is habitually shortened.

Discipline.

Discipline, which secures efficiency through obedience, is the strength of every military organization, and is established by the wise bestowal of privileges and rewards, by the infliction of punishments, and by drill, which forms the habit of obedience. But whereas the enforced obedience of the ignorant men of former times produced sufficient results, the recent improvements in all military branches demand a degree of intelligence and alacrity in the performance of duty which must be induced rather than enforced, and this must bring changes in the mode of discipline, some of which have already been indicated in speaking of a mode of payment depending on a system of rewards for proficiency.

There are now two principal privileges—monthly money and liberty. The reservation of pay has been already alluded to as a cause of preventing enlistments, but it is also injurious to discipline; for it lowers a man's self-respect when he is not trusted with his own, and there can be no greater absurdity and injustice than in paying as a privilege the wages which have already been earned. The entire monthly wages should therefore be paid every month as a right. Liberty depends altogether upon conduct, and in this particular, as in many others in the service, there is no recognized custom, every commanding officer following his own ideas on the subject. Drunkenness, the most common offense in the Navy, is closely connected with liberty; and with regard to its punishment, great latitude is allowed to captains. This diversity of treatment is injurious to discipline, and is a frequent cause of desertion, as it is very easy to ship on another vessel without identification. There should be a set of rules governing the privilege of liberty and the punishment of drunkenness, which should be closely adhered to by all the vessels of the Navy. Liberty should be granted to first-class-conduct men whenever their services are not required on board; and frequently to all.

Minor punishments are in the hands of the captain, but for all except the smallest offenses he must convene a summary court-martial. Any three commissioned officers on board the ship may compose one of these courts, which take cognizance of the class of offenses which come before police magistrates and award penalties of about the same degree.

The law seems to say that any three men bearing commissions, no matter how recent the commissions, nor how ignorant of naval law,

customs, and necessities the men may be, can execute naval justice better than a captain who has spent his life in the service and is thought fit to be trusted with the honor of the flag, the lives of his crew, and the safety of his ship. But there are many objections to summary courts. There is frequently a member anxious to display his knowledge of law even at the expense of justice: then, when a finding has been made, it is difficult to decide on a sentence, so that if several cases for the same offense come before the same court, there are frequently several different punishments awarded, each representing a compromise, or the views of an individual member of the court. Even when the court has finished its work, the revising officer may wish to show himself a lawyer and quash a well-deserved sentence on some trifling technicality. In a word, the formalities incident to summary courts hinder substantial justice, and powers vested in them should be committed to commanding officers; for if a man is fit to be trusted with command, he is surely fit to enforce the discipline by which he vindicates his trust. General courts-martial are open to the same objections as summary courts, but their duties and powers are too great to be all entrusted to one man. They should never consist of more than five or seven members, in order to increase the sense of individual responsibility and the dispatch of business, and to decrease their cost. The functions of general courts should cease after making the finding, thus assimilating their duties to those of civil juries. The commander-in-chief should have authority to send the proceedings back for revision, and to award sentences equal to those now awarded by summary courts, or else, in more serious cases, to send the offenders to the United States for sentence by the Secretary of the Navy through the Judge Advocate-General. In this way adequate punishments would be more frequently awarded, and the discipline of the Navy would be more completely under the control of the Secretary, who is responsible for the Navy in all its branches.

There are many occasions upon which subordinate officers find it necessary to take notice of trifling offenses scarcely worthy of reporting to the commanding officer. Under these circumstances it is easy to find some way of evading the regulations, punishing the man without avowing it, and this is generally done. Such proceedings cannot be favorable to discipline, for one always feels a sense of injustice at illegal punishment, no matter how well deserved. To provide for such cases, divisional officers should be permitted to

inflict certain small punishments in the way of extra duties and the like, which should be entered in a book for the captain's inspection as a check against abuse; but they should be in nowise prejudicial to the record or privileges of delinquents.

There should be a code of punishments carefully drawn up, after the manner of the civil code, prescribing a maximum and minimum punishment for each class of offense. This would do much toward obtaining uniformity of punishment, especially in the minor cases dealt with by commanding officers.

Finally, in the instruction of recruits, officers should pay great attention to the explanation of the .principles of military honor and devotion to duty, and thereafter no opportunity should ever be lost of inculcating them both by example and instruction, and by the mode of punishment selected for individual offenses. Our men are intelligent enough to respond to such ideas, which are more conducive to good discipline than anything else.

DRILL.

The drill of the Navy is at present unsatisfactory, for it does not realize the full measure of efficiency of which even our poor ships are capable. Drills are in charge of the various bureaus of the Navy Department, but there is no system about them, for one bureau may draw up instructions and manuals, while the returns from the ships are made to another; and, as was said before in this essay, a commanding officer hears quickly of an informality in his quarterly drill returns, although their substance seems to be a matter of indifference, and the Department's solicitude for a ship's efficiency apparently ends when she is commissioned.

On board ship we find the drills prescribed in the Ordnance Manual carried out in a perfunctory way, but the instruction given is inferior to the capabilities of the arms, and target practice amounts to nothing. With regard to all other drills there is absolutely no uniformity. Every squadron changes its sail and spar drills with a change of admirals, and the new flag lieutenant edits a new edition of the little book on routine, seamanship drills, and the signal book. Except by the marines, Upton's Infantry Tactics is scarcely more regarded than Luce's Seamanship; both are acknowledged to be very good authority on their respective subjects. In all drills, officers have no hesitation in departing from the usual or authorized

custom, if they think they can improve thereon. This should not be permitted, but manuals for all drills should be published by the Department and enforced by the inspectors, upon whom the efficiency of the Navy would greatly depend.

The objects of drill may be laid down as follows: To maintain discipline and *esprit de corps;* to instruct in the use of all weapons and in the management of the ship; to maintain a high standard of physical endurance, and to afford occupation and employment.

In former times discipline was simply the habit of obedience, formed by the constant repetition of manœuvres at drill, and enforced by brutal punishments; but general education and the habits of freedom have advanced so far in this country, and the intelligence demanded for the proper use of modern weapons is so great, that the old methods of drill and discipline are no longer suitable: henceforward we must reach efficiency not by attempting to form a habit of blind obedience, but by developing individual intelligence, self-reliance and resource, and by raising the self-respect of every man in the Navy, so that each one may feel that in an emergency he may depend upon his comrades as upon himself. At present, drill should partake very much of the nature of instruction, and the principles underlying every order and manœuvre should be carefully and thoroughly explained: duty will be much better executed in consequence. At the same time, this explanation of orders on the drill-ground or in the class-room must never be allowed to conflict with the disciplinary principle of unquestioning and unhesitating obedience.

The second object of drill—instruction in the use of weapons—is of an importance which need not be enlarged upon, yet it is precisely the one in which our Navy is most deficient. The men understand their rifles so little that a great many are rendered useless by careless handling, and they have no idea about shooting. The allowance for small-arm target practice is two shots a month, but even this is not always expended. Besides, the target is usually swung from the yardarm or towed astern, where it is impossible to verify hits. In the Army, twenty cartridges a month are allowed, with materials for reloading, so that in some companies every man expends as much as fifty or sixty shots a month at target practice, and there have been companies in which every man had the score of "marksman." The allowance for great-gun target practice is two shots a month a gun's crew. This allowance is nearer what it should be than that for small-arms, but the results in time of war of any expenditure in this direction are so great that the allowance should be increased.

The handling of the ship comprises two branches: naval tactics and seamanship. Naval tactics is a drill by which only officers profit, and absolutely nothing of it is known in our Navy; but seamanship belongs quite as much to enlisted men as it does to officers. It is claimed, indeed, that the latter is a thing of the past, belonging to the sailing fleets; and there are those who say that the resource and ingenuity which were eminently characteristic of the seamen of former times no longer exist, or belong only to those who have been brought up in sailing ships. There can be no doubt that the reason thus urged for maintaining a sailing training squadron is quite sound; but as the fleets of the future will be of steamers, the use of a sailing squadron will be like an education in a dead language. A modern squadron, properly exercised, cultivates so many accomplishments in its crews, that we may safely believe the seamen of the future will be as prompt in emergencies and as fertile in resources as their predecessors. Still, as our fleet yet depends in a great degree on sails, and there is no squadron of evolutions, it is quite too early to think of the abolition of the sailing training squadron. A most important object of drill is the maintenance of physical training. It is specially important for officers, because the men are in fair condition from their daily work; but the habits of officers are so sedentary, it is not too much to say that their physical training is not enough to fit them to lead their men in war. Any drill whose object is simply to afford occupation, as is sometimes desirable, should be such as to develop this important end.

Drills may be classified into personal instruction, divisional exercise, ship drill and squadron drill. Upon the thoroughness of the personal instruction given to recruits will depend all success in war. The recent developments of naval and military warfare follow very different lines, yet they have the common result of increasing very greatly the importance of the individual, which necessitates a correspondingly increased proportion of personal instruction in all drill. In the Navy this importance of the individual arises from the accuracy of weapons; from the decrease in the numbers of great-guns, rendering it impossible to depend for results upon an average of shooting where every shot ought to tell; and from the modern subdivision of ships, which requires every man to be self-dependent in order to meet the emergencies which may arise near him. Personal instruction is altogether out of place on board a man-of-war, where the entire organization is for service and not for a school. Cruising vessels, therefore, should never be permitted to recruit.

The barrack system, which was mentioned as favorable to discipline, is equally favorable to drill and to health, and should be adopted for the training school for boys. The general system of such a school should be similar in principle to that adopted at the Naval Academy, differing only in giving the boys a shorter course and a larger proportion of practical instruction and drill. The staff of this school should consist largely of petty officers, who should give instruction in practical work and should have a large degree of authority, thus teaching the boys from the first to respect and look up to them. The course should comprise the completion of a common-school education and practical instruction in gunnery, small-arms, seamanship, steam and signals. The theoretical instruction should be merely such as to enable the boys to understand the principles of their drill.

There should also be great attention paid to fencing and boxing, and every means should be taken to encourage these accomplishments as recreations. It is scarcely possible that we shall ever recur to boarding, but one of the Chinese vessels at Foo-Chow was so captured, and perhaps it may be useful in some exceptional case. In the meantime, broadsword exercise and boxing are manly accomplishments well adapted to shipboard, and developing judgment, temper, self-reliance and physique—precisely the qualities that are needed in a seaman. Every man-of-war should therefore be abundantly supplied with masks, single-sticks, and gloves, and officers should be obliged to exercise with them as well as the men, for they need it more to keep in training, and should always exceed their men in their knowledge of weapons and drill.

But instruction should chiefly be directed towards the management of weapons and machinery. The mechanism and nomenclature of all guns and small-arms should be fully explained; the precautions to be observed with ammunition and torpedoes should be taught, and the methods of connecting electrical wires, the use of switches, and other simple electrical information. With regard to the engines, every one should be taught how to start and stop a boat engine, and something about looking out for the boilers. It should never be forgotten that a good man-of-war's-man, besides knowing his own business well, should know something of everybody else's business.

The greatest pains should be taken with target practice, for good shooting is of vital importance, and the confidence begotten of skill reacts upon the shooting. It is impossible to develop the full capabilities of small-arms with the opportunities afforded for target practice

on shipboard, and therefore the importance of thorough instruction on shore is redoubled. Target practice should include the estimation of distances, the allowances for wind and speed, and shooting at every variety of target, such as at moving targets of various colors and with different backgrounds, at disappearing targets at different ranges, etc. Great-gun target practice need not be given at this elementary school, for it is too expensive for all to receive a thorough instruction. A course in it should be reserved for the best marksmen, and they should be instructed in the same thorough manner as in small-arm practice. A thorough basis of practical information having thus been laid, the divisional exercise should follow, to teach the recruits to work in unison and mutually support each other. They should be taught to handle the great-guns, to drill in the company and battalion, and special efforts should be directed towards securing the control of firing by means of sham fights. There should be much exercise in boats and steam launches, with practice in laying mines and searching for the enemy's mines, and in the use of the electric search-light in sweeping the horizon and estimating distances of torpedo boats and other objects, and in the duties of picket boats. With all this, the instruction in the routine duties of seamanship and the daily work of the ship should not be neglected; but it is unnecessary to enlarge upon these.

Recruits, having thus gone through the course at the training school, would be ready for seagoing ships, and should be transferred to the barracks at the navy yards to wait for a ship. Here they should perform such work in the rigging lofts and in fitting out ships as may be necessary, and should continue their drills.

On joining a ship the recruits would find themselves with a substantial basis of knowledge regarding their duties, and their services would be valuable from the first. They would have opportunities of selecting a specialty, and after three months' leave at the expiration of their cruise, they should return to the training school, there to follow an advanced course in one of the professional branches of steam, gunnery and great-gun target practice, or signals and navigating work; and on the degree of proficiency obtained in these courses should depend the amount of the supplements to the pay.

On board ship no drill should be permitted which does not directly contribute either to the safety and proper management of the ship or to her efficiency in battle. Target practice, signals, and fencing should be continually practised for the sake of maintaining individual effi-

ciency and physical training, and the divisional exercises would teach the men mutually to support and aid each other. These exercises should always be smartly carried out, and stupid men should never be permitted to interrupt their course, but should be turned over to a petty officer for instruction. It should be the effort of every individual officer to ascertain and develop the full capabilities of his division, and to ensure to himself a proper degree of control of the firing, if in the gun or torpedo divisions. When the officers and crew have become acquainted with the ship and with each other, the captain should proceed to exercise at ship drills. These include clearing for action, general and fire quarters, battalion, boat and seamanship drills. For the enlisted men these drills are little more than repetitions of the divisional exercises, but they are of great importance to officers, and the captain and executive officer should take great care in instructing them and in causing them to bring out the maximum efficiency of their commands. Seamanship drill is diminishing yearly in importance as the use of steam increases and spars become lighter and fewer; but it remains a favorite drill, as it affords an opportunity for active exercise and rivalry between ships. As, however, it no longer contributes to fighting efficiency, its prominence as an exercise drill should be taken by "Clear ship for action." Here we would have a display of seamanship in preparing the military masts and in hoisting out the torpedo boats; and below, the water-tight doors and armored hatches call for good organization to secure their efficiency. But the principal work would be with the torpedo netting. This has been proved indispensable for the protection of every ship at anchor, and to get it up, prepare it and rig it out quickly would be an excellent test of seamanship and efficiency. With regard to general quarters, it should be the captain's first effort to ascertain by experiment, and then to maintain by practice, the best means of establishing his control over the divisional officers, and of ensuring to himself the prompt receipt of intelligence from all parts of the ship. Beyond this, general quarters amounts to very little, except when manœuvring in sham fight with other vessels.

Night general quarters should take the form of an attack with torpedo boats, sending out the ship's torpedo boats to attempt a surprise, and at their discovery the ship should clear for action and go to general quarters. The use of the electric search-light and the way to profit by it should be studied by every one.

As for fire quarters, it does not seem as if fire could prove a very

threatening thing in iron ships minutely subdivided and with fixed hose-pipes. At all events, it should be dealt with by the people in the compartment with it, and the principal effort at drill should be directed towards securing prompt communication with the pumps, in order to have the water turned on.

Boat drill under oars and sail, and under arms with artillery, musketry and search-lights, with boat-squadron manœuvres, forms an important part of the battalion drill. The landing of the French at Sfax is an example of perfection in this particular and of the advantages to be derived from it. Battalion drill should be carried out with great thoroughness and with perfect uniformity throughout the service. The evolutions taught should be few, comprehending only those practical ones of service in war; but the duties of sentries, patrols and pickets, and of encamping, as well as the mode of landing and embarking, should be much dwelt upon, and every opportunity should be taken of practising them.

But there is another class of ship drills of benefit to officers only, and this is the manœuvring of the ship. Upon joining a ship, it should be one of the first duties of every officer to make himself acquainted with the particulars of her construction, armament and equipment, and with her nautical, tactical and combatant qualities and peculiarities. She should be constantly manœuvred until all the officers are thoroughly acquainted with the particular action of the screws upon the helm in backing, and until the tactical diameter is known and every one has some proficiency in estimating by the eye the curved course she will describe in trying to ram a passing adversary. To this end there should be much practice in trying to ram moving targets. This exercise is one to which special attention should be given at night, for then the value of the ram is at its maximum. Next, the ship should practise manœuvring in company with her torpedo boats, which should learn to cover themselves behind the ship, and how to keep clear of the ship's torpedoes while securing the efficiency of their own.

We now come to squadron drill. An evolutionary squadron is an absolute necessity for the proper drill and instruction of officers and men, and upon the thoroughness and completeness of the methods of the evolutionary squadron will depend all success in war. The squadron is further necessary as the only means for ascertaining the efficiency of the general system selected for the Navy, and the directions in which improvements are called for in construction, drill or

tactics. As examples of this latter use of the evolutionary squadron, the recent manœuvres of the Germans have convinced them of the complete reliability of their present system of coast defense by means of mines and torpedo boats supported by coast fortifications and a fleet. The English manœuvres of last summer taught them the value of the Polyphemus and Hecla types of vessels, and the necessity of altering the type of torpedo boat. Torpedo nettings also proved a complete success, and are henceforward indispensable. The Italian manœuvres of 1885 teach the tactical lesson that a fleet can derive no support from an unfortified harbor, no matter what its natural advantages.

For a squadron of evolutions, the North Atlantic is the most suitable, as it is the "home squadron." On all questions of custom, etiquette and drill not decided by the Regulations or Instructions, the usage of the evolutionary squadron should govern all others. All newly commissioned ships should join this squadron before going abroad, in order to drill and acquire the uniformity of style which is one of the most prominent evidences of discipline and efficiency. In this squadron is afforded the opportunity for the acquirement of nerve and skill in handling vessels, for learning the means of utilizing their armament and qualities to the best advantage and of defending them against attack and surprise.

In short, we make progress in naval science by approaching as closely as possible the conditions of actual warfare. On assembling the fleet, the admiral's first efforts should be directed towards establishing his control over it, through the adoption of a proper organization and grouping and the perfection of the methods of signaling. The imperfect method of the latter seems to offer one of the most formidable obstacles to the prompt and united action of the fleet. Squadron tactics and manœuvres should follow, in order to teach officers to maintain position and give them steadiness and skill in handling the vessels. In carrying out these manœuvres, the opportunity should be taken to develop scouting duties both by large ships and torpedo boats. These vessels should reconnoitre the coasts, examine harbors, and follow suspicious vessels. The electric light should be freely used as an offensive weapon to search the horizon and coasts. Attention should be paid to the estimation of distances both of vessels and landmarks by day and night. Then should come the combats of ship against ship, when the captains should direct their attention towards the peculiarities of their ships, and the best

mode of attack and retreat as developed against the various types of their adversaries. In these sham fights powder should be freely used, in order to examine the effects of the smoke and its influence on tactics, for this seems to be a most embarrassing accompaniment of battle. Then should come exercises of one ship against two, to show the pair the best way of supporting each other while the efforts of the single ship would be to separate them. Then the same set of manœuvres should be executed with the vessels supported by their respective torpedo boats. In port the squadron should exercise at establishing its defenses with nettings, booms, lines of torpedo mines and picket boats. The large vessels on scouting duty should learn to hide themselves under the shadow of the coasts, and not to betray themselves by too high a speed. In the recent English manœuvres the enemy was frequently discovered by the line of foam at the bows. The use of the electric light as a defensive weapon should also be studied, and the best way of illuminating the entire horizon when all the lights of the squadron are available. The duties of the torpedo boats as pickets and in reconnaissances are important, and they should also be employed in night attacks. The squadron should land the battalions with complete stores for taking the field, and the vessels should practise covering the landing with the guns, and with torpedo boats armed with machine guns. After landing, the battalion should divide into two parts and exercise in sham fights, and in embarking in the face of the enemy, and in all the duties of picketing and reconnoitring work. The attack of fortifications should be practised, by which the Army would profit as much as the Navy. This would exercise the squadron in indicating an unbuoyed channel, in removing obstructions by dragging and countermining, and would show the possibilities of forcing a passage through obstructions. The fleet should also divide into two parts, one acting as a support to the fortifications, and in this way most valuable aid could be given to the Army in regard to the fortifications at each port, and the fleet could learn the peculiarities of the principal ports. The torpedo flotilla should manœuvre in tactics, as a school for the younger officers; and as flotilla against flotilla there would be developed the peculiar tactics suitable for these small craft in attacking each other. They should learn how to avoid the torpedo chasers, and, as far as possible, should exercise all along the coast, in order that officers may be thoroughly acquainted with the intricacies of the entire coast. Finally, the divided fleet should manœuvre as opposing squadrons on the high

seas, using the support of torpedo boats, and approaching as nearly as possible the conditions of actual battle; and exercises should frequently take place at night. In all these sham battles every possible stratagem and deception should be used against the enemy, in order to teach constant vigilance and suspicion. A Chilian vessel was blown up in Callao by a seeming fruit boat, and last autumn one of the Italian squadron of evolutions was put out of action by a similar stratagem.

In conclusion, the points of this essay may be summed up as follows:

1st. As a ship, though composed of many parts, is yet one fighting machine, she should be entirely manned by one corps of officers and one corps of enlisted men, whose members should be acquainted with all duties on shipboard in a greater or less degree. But, in recognition of the great field thus opened, each should devote himself more particularly to the study of some specialty when on shore duty, and its practice when at sea. The lines between the specialities would be more deeply marked in the corps of enlisted men, because they would not rise to command, which of itself is a specialty embracing all others.

2d. As far as possible, good conduct, proficiency, and zeal should be obtained by offering a direct pecuniary reward to officers and men, and quicker promotion to able officers.

3d. Officers should be obliged to increase their professional knowledge by following special courses at a post-graduate school.

4th. A body of trustworthy, intelligent and responsible petty officers holding their positions securely is an absolute necessity.

5th. Discipline should be maintained by raising the self-respect and devotion of the men. They should be habitually granted every possible privilege and comfort, and punishments should be entrusted to responsible individuals rather than to courts.

6th. All drills should contribute directly to efficiency in war, either by improving knowledge and proficiency, or by developing physical training both of officers and men. All drill should be directed towards the development of individual intelligence, resource and self-reliance, rather than towards forming an instinctive adherence to routine.

It may be mentioned that there is no feature of this essay which does not find its counterpart or analogy in some other service.

UNITED STATES NAVAL INSTITUTE, ANNAPOLIS, MD.

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Commander P. F. HARRINGTON, U. S. N., in the Chair.

CORROSION OF THE COPPER OF THE JUNIATA.

BY CHARLES E. MUNROE.

On October 23, 1882, I received telegraphic orders from the Secretary of the Navy to proceed to New York and examine the Juniata, with the object of ascertaining the cause of the corrosion of her copper. On reporting there I found the Juniata in dry dock, and an examination of her copper showed that the immersed surface had become covered with a pale green, earthy-looking coating, which at the time had become dry in spots and blistered. Many of these blisters had split, and the coating had flaked off to such an extent that the floor of the dock was thickly strewn with them. While the outer surfaces of these scales were of an apple-green color, the inner was, in the main, of a copper-red color, though in some instances it was black. The surface of the copper where thus exposed was, in the main, of a copper-red color, but in some spots black. Where these black spots appeared they were imperfectly circular in shape.

In addition to this general action which had caused the incrustation over the entire wetted surface, it was found that several plates had been so corroded as to be nearly or completely perforated. Eleven sheets on the keel, and sixteen on the bottom, most of them below the turn of the bilge, were so badly corroded as to require removal, and there were many others which gave promise of being soon in the same condition. This corrosion did not involve the whole of the plate on which it existed, nor was every plate attacked, nor in most cases contiguous plates, nor did it, in any case observed, extend to the nails or about them. The action was so irregularly distributed about the bottom and on the surface of the plates attacked, that there

could be little doubt that the cause at work was a purely local one. When corrosion had gone on to the extent described, the outline of the spot was irregularly circular in shape, and the areas decreased unevenly from the outer surface inward, giving to the perforation an irregular cone-shape of very wide angle, the sides of the cone being in steps. The copper at these points seemed to be laminated.

Further inspection showed that a portion of the copper on the keel, and all of the copper on the rudder, was covered with a greenish incrustation which was harder, firmer, and more coherent than that on the remainder of the ship, and that this copper was *wholly* free from any evidences of corrosion. The portion on the keel was midway fore and aft at the top of the keel. It was a goring-shaped section, and, roughly estimated, it was fifty feet in length, and tapered from eighteen inches wide midway to a point at either end. Although this strip was wholly free from local corrosion, yet sheets of copper below it, on the keel, and above it, on the hull, were corroded as described. So on the stern there were several corroded sheets, while the copper on the rudder, immediately adjacent, was free from all evidences of it. From their location it was evident that this copper on the rudder and the top of the keel had been subjected to the same conditions of exposure after immersion as the remainder of the copper on the immersed surface.

The history of the Juniata was officially given as follows: When she had received her suit of copper, she was removed from the dry dock and lay in the Wallabout, under the iron derrick, for about five months; she was then moved to the wharf at the foot of Main street, near Store No. 30, where she lay for one and a half months. From there she was moved to the ordnance dock, where she remained three days; again moved to the foot of Main street, where she lay for a day and a half, and then was taken into the dry dock again. This was two days before I reported in New York. The corrosion noted had consequently taken place during the six to seven months in which the vessel was lying in the Wallabout. The copper on the rudder and the goring-shaped section on the keel were said to have been a portion of the old suit of copper which had been put on at the League Island Yard many years before. The goring-shaped piece owed its form to the fact that the ship was "hogged," and when pieces were inserted to straighten up the keel, it was thought unnecessary to strip the old copper from the old keel.

My attention was next turned to the examination of the new, unused

copper from which the copper for the Juniata had been taken. I first, while examining the bottom, inquired of the workmen if they had noticed any peculiarity in the appearance of the copper as they put it on, and I found that they had remarked upon the "picturing," as they termed it, which seemed to be unusual. I applied then for sheets of copper from the same batch, and found that a few remained in the storehouse. On inspection I found that this "picturing" of which the workmen spoke was in the form of irregularly circular black spots and streaks on the surface of the copper. My first impression was that these spots were probably due to the fact that during transportation moisture had gathered on the surface of the plates, and that this moisture had absorbed hydrogen or ammonium sulphide from the bilge gases of the ship in which they were transported, and that this had tarnished them; but on examining the spots by light reflected at a wide angle, and by the sense of touch, it seemed probable that the plates had been rolled since the spots were formed, since the lustre on the spots was quite as brilliant as elsewhere on the surface. This theory of staining was not credited in the Constructor's Department of the Yard, as it was generally understood that the sheets were in this condition when put aboard the transport boat.

I next directed my efforts to tracing up the history of the Juniata copper. I hoped to ascertain when it was received and where it was rolled; then from the marks upon the sheets to learn from what batch of copper it had come; then to follow up these cakes to the smelting works, and from this point determine the source and character of the ore from which it was made. With this knowledge of the source of the copper and the various processes through which it had passed, I hoped to discover the source of any physical or chemical imperfections which the sheets might contain; but at the outset I found that there were no marks upon these sheets of copper by which they could be identified, and that the different invoices received at the New York Yard were so mixed as to be indistinguishable. All that I could learn was that all of the sheathing used was rolled at the Washington Yard. Since such difficulties as have arisen in the case of the Juniata's copper are likely to recur, it will assist materially in discovering the source of the difficulty if the history of the copper is known. I would recommend that hereafter a full record of the copper should be kept, and that each sheet should be stamped in the upper left-hand corner with the number of the batch from which it comes. This mark will be preserved by the lap of the sheet above. That this is feasible is

shown by a sheet of the old copper, stripped some two years previously from the Brooklyn, after it had been some years in service, which bears distinctly the following mark in left-hand upper corner, "U. S. N. Y. W., 1866." Starting from this point it will then be possible to compile from the log-books of a ship such statistics regarding the time the copper has been in use, and the conditions to which it has been exposed, as will enable us to determine the average life of copper sheathing—an important fact about which there now seems to be considerable uncertainty.

I next examined the Wallabout, a crescent-shaped body of water, something over 400 feet wide, lying between the Navy Yard proper and the cob dock. With the flood tide the current passes through to the westward, and with the ebb tide it moves to the eastward. Emptying into it are three sewers. At the east end, opposite the ordnance dock, is the Williamsburgh sewer, which drains 2300 acres of improved property, a considerable part being covered by petroleum refineries, chemical works, sugar refineries, and the like. About 500 feet from the dry dock the Brooklyn sewer, which traverses the Navy Yard, empties into the Wallabout. This drains an area of about 550 acres of improved property largely covered by residences. Near Store No. 30 a small sewer empties which drains a portion of the Navy Yard; and near the west end of the Wallabout the Hudson-avenue sewer, which drains 472 acres of Brooklyn, empties. The result of all this sewage flowing into the Wallabout is to modify very considerably the character of the sea water. The first effect observed is that which always takes place where sewage, charged with dissolved and suspended matter, flows into salt water—viz.: the precipitation of the suspended and dissolved matter and the formation of mud banks. This is going on continually in the Wallabout, and one of the largest banks was formed under the iron derrick where the Juniata lay for about five months. So shoal was it that she rested in the mud at low water, and in fact was probably imbedded in it for the greater part of the time. From this bank I gathered specimens of the mud, and I also got specimens of the bottom from off the ordnance dock. The first was regular dock mud, but the second consisted largely of coal tar. This last was accounted for by the existence, about opposite, of two large gas works, the "People's" and the "Nassau," while at the west end of the Wallabout there is a third. From the Williamsburgh and the Brooklyn sewers samples of sewage were taken. The color and character of the

sewage as it flowed from the sewers showed that the first was from factories, while the second was largely from dwellings. All the samples of sewage and mud were tested immediately after gathering, and all were found to be slightly *acid.* Naturally the character of the sewage flowing in, and consequently of the water in the Wallabout, will vary with the season, the day, and the state of the tide, so that the examination of only one set of samples is not of any value, except as indicating the character of the water at the time they were gathered. Realizing this, I applied to the Health Department of the city of Brooklyn, and also to Professor Charles F. Chandler, President Board of Health of New York, for information concerning the sewage emptying into the East River, but no investigation of this sort seems to have been made. Professor Chandler says, however, "There are a great number of petroleum refineries on Long Island at Hunter's Point and at Newtown Creek, and these refineries use enormous quantities of sulphuric acid, some portions of which find their way into the river. There are also chemical factories in Brooklyn—quite a number of them—and possibly their refuse materials are discharged from the sewers, by which the water along that shore may be rendered quite different from ordinary sea water." Through the courtesy of Civil Engineer F. C. Prindle, U. S. N., and Mr. J. H. Raymond, Commissioner of Health of the city of Brooklyn, I have obtained much of the information concerning the sewers which is given above. It would seem likely that considerable ammonia would reach the Wallabout from the gas works, were it not that ammonia has become so valuable an article, and the processes for recovering it from gas works have become so improved as to prevent much of it being allowed to escape. It is probable, too, that the considerable deposit of coal tar discovered at the end of the ordnance dock accumulated before these by-products of gas-making had become of any commercial value.

Besides the specimens of mud and sewage, one sheet of new copper from the lot from which the Juniata's copper was probably taken, five corroded sheets stripped from the Juniata, a strip of the copper from the rudder of the Juniata, and a sheet of the old copper which had been stripped from the Brooklyn when she was last recoppered here, were taken for examination.

Before leaving the Navy Yard I examined the pile of old copper stripped from the Brooklyn when she was last repaired. Although this had been in service many years (just how long I could not ascer-

tain), much of it was so strong that it drew out the nails in coming off. Some of the sheets were eaten through in much the same way as was seen in the Juniata's copper, but there were very few of them. Naval Constructor W. L. Mintonye, U. S. N., informed me that sheets of this old copper had been used for covering the anchor hoy used in the Wallabout, that these sheets had been in use thus for about two years, and that during that time the anchor hoy frequently rested on the mud banks, yet the copper was sound. Mr. Mintonye also described some experiments which he had made with the Juniata's copper. He took sheets from the lot with which the Juniata was sheathed, and coupled them in pairs by blocks of wood. At the time the Juniata was coppered he buried one of these pairs in the mud; the second was suspended six feet from the surface of the water, and the third was suspended at the surface of the water at low-water mark. These couples remained until the Juniata was docked in October, 1882. They were then taken out, and all were found unchanged except the couple buried in the mud, and these were only tarnished.

During my inspection of the bottom of the Juniata, I was accompanied by Chief Constructor T. D. Wilson, U. S. N., and he suggested in explanation of the corrosion that it was due (1) to iron coming in contact with the copper, and that this probably occurred while the Juniata was lying in the mud bank under the iron derrick, as it was rumored that iron chains and other iron articles had been lost in this mud bank from time to time. Since my visit to the Navy Yard this mud bank has been removed by dredging, but I cannot learn that any such articles have been recovered.

Another theory (2) advanced to account for the corrosion is that it was due to the sewage which flows into the Wallabout in such quantity. This was evidently in mind when my orders were drawn, as they read: "Your attention is called to the fact that a large sewer discharges into the Wallabout at a point near the wharf to which the Juniata has recently been moved."

Another (3) is that it was due to impurities in the copper, arising either from imperfect refining, impure ores, or the intentional admixture of foreign and cheaper metals.

Another (4) is that it was due to iron removed by abrasion, or in the form of rust, from the rolls in the rolling mill.

Another (5) is that it was caused by the adhesion of coal tar.

Another (6) is that it was due to physical or chemical differences

in different parts of the copper, which were caused by the method of manufacture.

On the 6th of December, 1882, in obedience to orders I proceeded to Washington, and there examined the sheets of corroded copper from the U. S. S. Brooklyn which were sent from Rio Janeiro. The corroded sheets presented practically the same appearance as those from the Juniata. There was the same irregularly circular outline, and the corrosion was seen in all stages, from a roughened surface at the outer edge of the circle to a thin edge at the centre. Through the courtesy of the Chief of the Bureau of Construction, I examined the report of the condition of the Brooklyn, with the accompanying drawings. These sketches showed that there was no regularity in the distribution of the corrosion, though most of the corroded sheets were below the turn of the bilge.

On the 9th of December, in obedience to orders, I proceeded to New York to examine the U. S. S. Trenton, then in dry dock. On inspection I found her copper to be in a very sound condition, so far as local corrosion was concerned, the only corroded plates being six about each of the Kingston valves, one plate on the starboard side in contact with the stern being roughened, but not pierced, and one on the port side forward, just below and in contact with the ram. Besides these there were a few plates which had been indented and torn slightly, probably through colliding with some object. In addition I found that one sheet had been removed from the garboard strake on the port side, about 60 feet aft. I could not learn why this plate had been taken off.

The history of this copper, so far as I could gather it, is as follows: The Trenton was in commission in Europe for some years, and on her return in October, 1881, she was laid up at the New York Yard. I am informed by her commanding officer, Captain F. M. Ramsay, U. S. N., that when she was brought in she was laid alongside the iron derrick, and she was so heavily loaded that it was with great difficulty that she could be forced into the mud bank under the derrick. After lying there some time she was drawn out into the Wallabout, and from that time until she was put into the dry dock in December, 1882, she lay nearly opposite the mouth of the Brooklyn sewer. The conditions, then, to which her old copper was subjected were almost identical with those to which the Juniata's new copper was subjected, the chief difference being that as the Trenton was heavily loaded, while the Juniata was light, the Trenton probably sank much deeper in the mud bank than the Juniata did.

On December 20, 1882, in obedience to orders, I proceeded to Washington to inspect the rolling mill at the Washington Navy Yard, then in operation. Here I witnessed the operations of hot rolling and scaling, and my attention was particularly attracted to the latter process, as it did not seem to be complete, some portions of the scale being adherent after the removal from the bath, necessitating the cleaning of the sheet as completely as possible by mechanical means. As the treatment with the lye and acid was done in a very crude way, by rubbing on with a broom, this may account in a measure for the failure to entirely remove the scale or oxide. During my visit I was the recipient of courteous attentions from Commodore T. Pattison, U. S. N., commanding, and from Naval Constructor S. H. Pook, U. S. N., in charge of the rolling-mill, and the latter permitted me to take copies of letters, of recent date, from the managers of some of the principal rolling-mills in the country, from which I extract the following:

Park, Scott & Co., Lake Superior Copper Mills, Pittsburgh, Pa., say: "The rolls in our mills which have given the most satisfaction are semi-steam-chilled." "We are not experienced as to what action sea water may have on sheathing made with iron rolls."

C. G. Hussey & Co., Pittsburgh Copper and Brass Rolling Mills, Pa., state: "For rolling copper we use principally the chilled iron rolls, and as far as our experience has gone we find them well adapted for the work. We never knew of any iron from the rolls adhering to the copper, but black spots may be on the copper from imperfect removal of the scale or oxide. That is the only way we can account for black spots or marks."

Hendricks Brothers, New York, write: "We consider chilled-iron rolls the best for the purpose referred to, and when replacing any at our own works, do so with those of that description. The rolling of copper in iron rollers is not detrimental for sheathing, nor would they injure it in any way as regards the action of sea water. The black spots spoken of are not iron, but copper scale or oxide, and do not affect the quality. Copper may be of equal purity, but some are harder than others; the latter are preferred for the sheathing for vessels, on account of the action of salt water upon it."

Pope & Cole, Baltimore, Md., write: "The only suitable material for the construction of rolls for rolling copper is *best iron, chilled.* The arrangements for rolling copper at the Washington Navy Yard are, in our judgment, so good that some time since we availed of permis-

sion from headquarters to make copies of the working drawings in your mill, with the purpose of constructing one here, upon your method, in place of our present mill. The methods and surroundings of rolling copper have nothing whatever to do with the action of sea water upon copper sheathing on vessels. The trouble in cases where copper sheathing has become *honeycombed* or *quickly worn thin* when in contact with sea water is attributable to the fact of the presence of a little silver in copper, which is quickly attacked by salt water. Copper for rolling can be procured which has no silver whatever in it—not a trace. The black specks or spots which you referred to are not iron: they are the oxide of copper. Copper and oxygen have a wonderful affinity for each other, especially when copper is hot or in a molten state. The oxide of copper, or, as known in commerce, "copper scale," is easily removed from sheets by "pickling," and ought to be wholly removed before your sheets are cold-rolled. If you will heat a piece of bright polished copper and then expose it for one moment to the atmosphere, it will so quickly absorb oxygen therefrom as at once to become as black as iron."

During this visit I received the following information from the executive officer of the Powhatan. "The Powhatan was lying at the wharf of the Brooklyn Navy Yard, near the iron derrick, from November 15, 1879, to January 23, 1880, and from December 23, 1880, to March 24, 1881. Shortly after each of the above occasions of her stay off the Navy Yard she went into the dry dock, and upon examination the copper on the bottom of the vessel was found in perfectly good condition." The conditions of exposure of the Powhatan evidently differed from those of the Juniata only in the fact that the latter was lying in the Wallabout during the summer months, while the former was there during the winter. This would to an extent probably modify the action.

On December 28, 1882, Commodore Pattison, U. S. N., sent me the following samples: Ingot copper, Pope & Cole; ingot copper, Hendricks Bros.; copper cake, Pope & Cole; copper cake from refuse copper refined at the Washington Navy Yard. The ingot copper from Pope & Cole was full of air-holes; the rest of the samples were sound, fine-grained, and quite free from air-holes or cavities, the specimen from the Washington Navy Yard being especially so.

On December 12, 1882, I received the following letter:

BUREAU OF ORDNANCE, NAVY DEPARTMENT,
WASHINGTON CITY, *December* 11, 1882.

Professor CHARLES E. MUNROE, *Chemist, U. S. N. Academy.*

Sir:—In connection with the condition of the copper sheathing on the Brooklyn, I beg leave to say (as probably throwing some light on the subject) that the copper on the ferryboat Billow, at the Torpedo Station, put on in May last, is very badly pitted.

This metal was furnished by the Bureau of Construction and Repairs, and the following analysis made* at the Torpedo Station shows that it contains foreign matters:

	Per Cent.
Copper	98.492
Lead	0.172
Arsenic	0.290
Nickel	0.102
Cobalt	0.010
Iron	0.570
Oxygen	0.240
Zinc	0.272
	100.148

Also traces of silver and antimony.

This copper may have been taken from the same lot from which the Brooklyn was coppered. The Bureau will be glad to make other analyses of copper, if desired. I am, sir, your obedient servant,

MONTGOMERY SICARD,
Chief of Bureau.

In reply to my inquiry as to the conditions to which the Billow had been subjected, Capt. T. O. Selfridge, U. S. N., commanding the Torpedo Station, states that "the Billow never has been aground since the copper was put on, and that she has only been exposed to the action of pure sea water."

Learning that there had formerly been trouble from the water of Baltimore Harbor, I addressed a prominent shipbuilding firm there, and received the following reply:

BALTIMORE, MD., *December* 14, 1882.

C. E. MUNROE, *Professor, U. S. Naval Academy.*

Dear Sir:—Replying to your favor of 9th instant in reference to the corrosion of copper and metal on vessels' bottoms in Baltimore Harbor, we would state that previous to the stopping of the sugar refineries and the deepening of our harbor, all the steamboats whose landings were in the vicinity of the refinery or at the foot of the street where the sewage of the latter was discharged,

* By Professor J. Fleming White.

suffered very much, and had to be docked for repairs or renewal of metal once each year, and in some cases at the refinery wharves twice in one year. The metal would be eaten worst at the water line around the nails in the seams of the plates. Some of the boats that used iron for protection against ice put it on in the fall and had to remove it in the spring, because it would be eaten away at the water line and interfere with the boats running. All these boats now run two, three and four years without docking, and, if they have pure copper on, we find it good after four years. We have some cases that we attribute to inferior metal. One we have just completed, the ship St. Albans, engaged in the Atlantic trade, metal been on twenty-six months, in active use eighteen months, honeycombed badly and had to be removed; should have lasted forty months. Yours respectfully, etc.,

William E. Woodall & Co.

In considering the case of the Juniata we must bear in mind that it is to be expected that copper sheathing will corrode in use, and that the peculiar advantage which it offers for keeping a ship's bottom clean is due to the fact that the copper is acted upon by sea water and forms a salt which, as it dissolves or scales, carries off the barnacles or seaweeds with it, and that this corrosion goes on over the whole immersed surface and continues throughout the whole period of immersion.

What takes place with sound copper in pure sea water will occur in any solvent in which the copper is immersed. If there is no contact with other bodies, solid or gaseous, and no marked currents formed in the liquid, corrosion will take place equally over the whole surface of the copper, though the speed of the corrosion may differ with the solvents.

What is peculiar about the corrosion of the Juniata's copper is that it was local and abnormally rapid. We will now take up the various theories proposed to account for this.

1 and 4. That it was due to contact with iron.

On January 22, 1824, Sir Humphry Davy said: "The rapid decay of the copper sheathing of His Majesty's ships of war, and the uncertainty of the time of its duration, have long attracted the attention of those persons most concerned in the naval interests of the country. Having had my inquiries directed to this important object by the Commissioners of the Navy Board, and a Committee of the Royal Society having been appointed to consider of it, I entered into an experimental investigation of the causes of the action of sea water on copper.

"It has been generally supposed that sea water had little or no

action on pure copper, and that the rapid decay of the copper on certain ships was owing to its impurity. On trying, however, the action of sea water upon two specimens of copper sent by John Vivian, Esq., to Mr. Faraday for analysis, I found the specimen which appeared absolutely pure was acted upon even more rapidly than the specimen which contained alloy; and on pursuing the inquiry with specimens of various kinds of copper which had been collected by the Navy Board and sent to the Royal Society, and some of which had been considered as remarkable for their durability, and others for their rapid decay, I found that they offered very inconsiderable differences only in their action upon sea water; and, consequently, that the changes they had undergone must have depended upon other causes than the absolute quality of the metal.

"When a piece of polished copper is suffered to remain in sea water, the first effects observed are a yellow tarnish upon the copper and a cloudiness in the water, which take place in two or three hours. The hue of the cloudiness is first white; it gradually becomes green. In less than a day a bluish-green precipitate appears in the bottom of the vessel, which constantly accumulates, at the same time that the surface of the copper corrodes, appearing red in the water, and grass-green where it is in contact with air."

Pursuing his experiments, Davy showed that there must be free oxygen present in water in order that copper might corrode, for "copper in sea water deprived of air by boiling or exhaustion, and exposed in an exhausted receiver or an atmosphere of hydrogen gas, underwent no change, and an absorption in atmospherical air was shown when copper and sea water were exposed to its agency in close vessels."

From his investigations Davy ascertained that when copper, in contact with a metal which was electro-negative to it, was exposed to sea water, the electro-negative metal was attacked, and the copper was free from corrosion until the other metal was destroyed; and he proposed to protect sheathing by this means. "In pursuing these researches and applying them to every possible form and connection of sheet copper, the results were of the most satisfactory kind. A piece of zinc as large as a pea, or the point of a small iron nail, was found fully adequate to preserve forty or fifty square inches of copper, and this wherever it was placed, whether at top, bottom, or in the middle of the sheet of copper; and whether the copper was straight, or bent, or made into coils. And where the connection between

different pieces of copper was completed by wires, or thin filaments of the fortieth or fiftieth of an inch in diameter, the effect was the same: every side, every surface, every particle of copper remained bright, whilst the iron or the zinc was slowly corroded.

"A piece of thick sheet copper containing on both sides about sixty square inches was cut in such a manner as to form seven divisions, connected only by the smallest filaments that could be left, and a mass of zinc of the fifth of an inch in diameter was soldered to the upper division. The whole was plunged under sea water; the copper remained perfectly polished. The same experiment was made with iron; and now after the lapse of a month, in both instances, the copper is as bright as when it was first introduced, whilst similar pieces of copper undefended in the same sea water have undergone considerable corrosion, and produced a large quantity of green deposit in the bottom of the vessel.

"A piece of iron nail about an inch long was fastened by a piece of copper wire nearly a foot long to a mass of sheet copper containing about forty square inches, and the whole plunged below the surface of sea water; it was found, after a week, that the copper defended the iron in the same manner as if it had been in immediate contact.

"A piece of copper and a piece of zinc soldered together at one of their extremities were made to form an arc in two different vessels of sea water, and the two portions of water were connected together by a small mass of tow moistened in the same water; the effect of the preservation of the copper took place in the same manner as if they had been in the same vessel." (*Phil. Trans.* 1824, p. 151.)

On p. 242 *Phil. Trans.* 1824 Davy gives a report of additional experiments on the protection of copper sheathing. He says: "Sheets of copper defended by from $\frac{1}{40}$ to $\frac{1}{1000}$ part of their surface of zinc, malleable and cast iron have been exposed for many weeks in the flow of the tide in Portsmouth Harbor, and their weights ascertained before and after the experiment. When the metallic protector was from $\frac{1}{40}$ to $\frac{1}{150}$, there was no corrosion nor decay of the copper; with smaller quantities, such as from $\frac{1}{200}$ to $\frac{1}{400}$, the copper underwent a loss of weight which was greater in proportion as the protector was smaller; and, as a proof of the universality of the principle, it was found that even $\frac{1}{1000}$ part of cast iron saved a certain proportion of the copper.

"The sheeting of boats and ships protected by the contact of zinc, cast and malleable iron in different proportions, compared with that

of similar boats and sides of ships unprotected, exhibited bright surfaces, whilst the unprotected copper underwent rapid corrosion, becoming first red, then green, and losing a part of its substance in scales.

"Fortunately, in the course of these experiments it has been proved that cast iron, the substance which is cheapest and most easily procured, is likewise most fitted for the protection of copper. It lasts longer than malleable iron or zinc; and the plumbaginous substance which is left by the action of sea water upon it retains the original form of the iron, and does not impede the electrical action of the remaining metal."

In *Phil. Trans.* 1825, p. 328, Davy gave the results of his "Further Researches on the Preservation of Metals by Electro-Chemical Means." He said: "As long as the whole surface of the copper changes or corrodes, no such adhesions (barnacles, etc.) can occur; but when this green rust has partially formed, the copper below is protected by it and there is an equal action produced, the electrical effect of the oxide, submuriate and carbonate of copper formed being to produce a more rapid corrosion of the parts still exposed to sea water; so that sheets are often found perforated with holes in one part, after being used five or six years, and comparatively sound in other parts.

"There is nothing in the poisonous character of the metal which prevents these adhesions (barnacles, etc.). It is *the solution* by which they are *prevented—the wear* of the surface. Weeds and shell fish readily adhere to the poisonous salts of lead which form upon the lead protecting the fore part of the keel; and to the copper, in any chemical combination in which it is insoluble.

"In general, in ships in the Navy, the first effect of the adhesion of weeds is perceived upon the heads of the mixed metal nails, which consist of copper alloyed by a small quantity of tin. The oxides of tin and copper which form upon the head of the nail and in the space round it defend the metal from the action of sea water; and being negative with respect to it, a stronger corroding effect is produced in its immediate vicinity, so that the copper is often worn into deep, irregular cavities in these parts.

"When copper is unequally worn, likewise in harbors or seas when the water is loaded with mud or mechanical deposits, this mud or these deposits rest in the rough parts or depressions in the copper, and in the parts where the different sheets join, and afford a soil or

bed in which seaweeds can fix their roots, and to which zoophytes and shell fish can adhere.

"As far as my experiments have gone, small quantities of other metals, such as iron, tin, zinc or arsenic in alloy in copper, have appeared to promote the formation of an insoluble compound on the surface, and consequently there is much reason to believe must be favorable to the adhesion of weeds and insects."

Up to July, 1824, all Davy's experiments had been tried in harbor in comparatively still water, but soon after the protectors were tested on a steam vessel in the North Seas, and it was found that sheets of unprotected copper one foot square lost about 6.55 grains in passing at a rate of eight miles per hour in twelve hours; but a sheet of the same size defended by rather less than $\frac{1}{500}$ lost 5.5 grains, and like sheets defended by $\frac{1}{70}$ and $\frac{1}{100}$ of malleable iron each lost 2 grains. These experiments show that there is a mechanical wear of the copper in sailing, and which, on the most exposed part of the ship and in the most rapid course, bears a relation of nearly 2 to 4.55. The copper sheets used weigh from 7000 to 8000 grains, and the balance would detect a difference of $\frac{1}{100}$ of a grain in carrying this load.

Further experiments showed that when air was excluded from a vessel containing sea water in which iron and copper or other corrodible metals were immersed, no action took place, and that the addition of an alkaline substance, even in presence of air, was sufficient to arrest corrosion; but if the solution was *strongly* alkaline, then the electro-chemical action was reversed and the copper was corroded while the iron was preserved. The results of applying protecting masses of iron to coppered ships are cited, and the effect seems to have been advantageous; but no instance is given where it had been tested for any long period.

In closing he says: "The copper used for sheathing should be the purest that can be obtained; and in being applied to the ship, its surface should be preserved as smooth and equable as possible; and the nails used for fastening should likewise be of pure copper; and a little difference in their thickness and shape will easily compensate for their want of hardness."

In the *Comptes Rendus*, **59,** 15; 1864, M. Becquerel reviews Davy's work, and records the work which he himself carried on at Toulon under the direction of the Minister de la Marine, which confirmed the views as to the protective action of iron on copper when immersed in sea water.

In the *Trans. Inst. Nav. Arch.* **10**, 166; 1869, John Grantham, Benjamin Bell, Charles Lamport, John Scott Russell and C. F. J. Young, all testify to the destruction of iron in contact with copper, and the latter quotes Faraday, Wood, Normandy, Selwyn and Siemens in support of his views. These conditions, however, only hold true for sea water in an acid or neutral condition. At the time of my visit to the Wallabout I found the water and mud slightly acid, and if this be the prevailing condition of the Wallabout, it is impossible that the corrosion of the copper could have been due to the presence of iron.

But while this relative action holds good for acid and neutral solutions in general, in most alkaline solutions, and especially solutions of the alkaline sulphides, the reverse is true, and the copper becomes electro-positive and is dissolved, while the iron remains unacted upon. Davy pointed this out in 1812 (*Chemical Phil.*, p. 148), and again in 1825 (*Phil. Trans.*, p. 339); and Faraday, in his *Experimental Researches in Electricity*, Vol. II, p. 86, gives tables of the electro-chemical series for different solutions which show these facts. In order to test these statements I made experiments, taking solutions of ammonium carbonate and Severn-River water, and ammonium sulphide and Severn water. In each of these I inserted a strip of iron and one of copper in contact with each other and allowed them to stand. In 24 hours there was evidence of corrosion on the copper, and in one case where the action had gone on for two months the copper was eaten off to the surface of the liquid, and copper was deposited on the iron. The solution contained 10 cm. of yellow sulphide of ammonia of the ordinary strength to 200 cm. of water, and during the time spoken of the solution was in an open flask in a dimly-lighted hood. No quantitative experiments were made, since it was not important for this research in the case of the ammonium carbonate, and in the case of the ammonium sulphide the coating of sulphide on the copper made it difficult to determine the loss with any degree of accuracy.

In determining if such a condition of circumstances could occur in the Wallabout, we may learn something from the examination of the sewage waters and mud. The sewage water taken at the mouths of the sewers was collected in patent-stoppered lager-beer bottles, which were carefully rinsed with the water to be collected. Although tolerably free from odor when collected, by the time they reached Annapolis they were highly charged with gases, which proved to be

largely sulphide of hydrogen and some sulphide of ammonium. Through the decomposition they had become much more turbid from suspended matter than when first collected. So great was the pressure upon the bottles that, though they were kept in a cool place, one of them burst under the pressure of the confined gases. The sewage had become alkaline when it reached Annapolis. I give below the analyses of these waters, filtered, and of the sedimentary matter, and I add an analysis of the Severn-River water, since I used this in some of the experiments. The analyses given hereafter are usually the mean of several:

	Parts in 100,000.					
	Solids.			Ammonia.		
	Vol.	Non-vol.	Total.	Am.	Al. Am.	Salt.
Williamsburgh.....	261.6	583.6	845.2	.1420	.1250	385.5
Brooklyn............	118.6	160.8	279.4	.0758	.0472	135.2
Severn........	157.0	1236.0	1393.0	......	......	1054.7

SUSPENDED MATTER.

	Parts in 100,000.		
	Vol.	Non-vol.	Total.
Williamsburgh	31.2	84.0	114.2
Brooklyn	22.6	38.1	50.7

The result of such sewage as the above flowing into salt water must be, not only the production of mud banks, as stated above, but also the generation of hydrogen sulphide and alkaline sulphides, for the salt water contains calcium sulphate (in pure sea-water it will rise to 100 parts in 100,000), and when organic matter comes in contact with this, calcium sulphide is formed, which gives off its sulphur as hydrogen sulphide when it comes in contact with the carbon dioxide of the air. Ammonium sulphide will then be formed through reaction with the sewage.

MUD.

The mud was stored in new paint-kegs immediately after collecting, and on arrival here it was transferred to air-tight glass jars. When the mud from under the iron derrick was dried, it was of a bluish-white color and contained a considerable number of shells. It effervesced somewhat with acids, and when moistened it had a claylike appearance. On drying, it gave off a slight offensive odor of animal matter. The mud from off the ordnance dock appeared, on drying, to be a mixture of blue mud with coal tar, and gave off the

odor of coal tar on drying. The mud from the iron derrick lost 15.23 per cent. of volatile matter on ignition, while the mud from the ordnance dock lost 24.51 per cent. When treated with ether, both yielded a yellow extractive matter, which on evaporation gave off an acrid odor. Both samples after exposure became alkaline.

We see, then, that in the sewage emptying into the Wallabout we have materials for the formation of ammonium and other sulphides, and that, although at the time of my visit there the water was acid to neutral, yet, under the varying conditions prevailing, it is possible there are times when it may be alkaline. Is it, then, probable that iron in alkaline solution was the cause of corrosion? I think not, and for the following reasons:

If iron had fallen into this mud bank, it is probable that owing to its greater relative weight it would sink through the soft mud to the bottom. Now, there was considerable difference in height between the corroded plates highest up on the hull and those on the keel, and if the Juniata touched bottom on the keel, the iron in contact with the higher plates must have been buoyed up. Since, however, there was room for the much heavier Trenton to get in, it is probable that the Juniata did not touch hard bottom. This argument may, however, be met by supposing that both the vessels lay on the flat of the bilge in a trough in the bottom of the Bay.

Another consideration is that the corrosion is too local for simple contact. None of the holes were over two inches in diameter, nor the roughened spaces about them more than eight inches. Now, copper is a good conductor, and with sheets as thick as these it seems strange that the action should be confined to so small an area. I do not lay much stress on this point.

What seems to me conclusive is that both the Powhatan and the Trenton lay in the same berth without injury, and that the copper on the rudder of the Juniata and the goring-piece on the keel were under precisely the same conditions as the remainder of the copper on the Juniata, and they were not corroded; and finally, that the copper on the Billow was corroded in a similar way without having been exposed to like surroundings.

2. That it was due to sewage. Since household sewage may contain sodium carbonate and hyposulphite from the soap used, and zinc chloride and bleaching powder from the disinfectants employed, I tested the action of these substances upon both copper and oxide of copper, the substances and the solutions being enclosed in stoppered bottles. The following are the results after seven months' action:

Copper and sodium hyposulphite—copper coated with sulphide—no copper in solution.

Copper oxide and sodium hyposulphite—no copper in solution.

Copper and sodium carbonate—copper coated with green carbonate—considerable copper in solution.

Copper oxide and sodium carbonate—faint trace of copper in solution—the copper oxide unchanged in appearance.

Copper and zinc chloride—deep green deposit of copper chloride on sides of bottle—copper bright.

Copper oxide and zinc chloride—no action.

Copper and bleaching powder—copper coated with bluish coat—copper in solution.

Copper oxide and bleaching powder—trace of copper in solution.

All of these substances act upon the copper, but the last two would be destroyed by the organic matter in the Wallabout, and the first two would probably not exist any length of time in their original condition. But granted that any of them were present and free to act, or that there were free acids or ammonia or ammoniacal salts present, could they produce such corrosion as took place on the Juniata? In my opinion not, because they would be dissolved in the water or in a layer at the surface, and would produce corrosion over the entire immersed portion of the copper or else at the water line, while that of the Juniata was purely local and confined to widely and irregularly separated spots.

3. That it was due to impurities in the copper arising from imperfect refining, impure ores, or the intentional admixture of foreign and cheaper metals.

In the paper by Davy quoted above, it will be seen that the presence of iron, tin, zinc, arsenic and the like, in small quantities, promoted the formation of insoluble scale on copper. In Pope and Cole's letter we see that they attribute corrosion to the presence of silver. This view was advanced by A. A. Hayes (*Am. Jour. Sci.* [2] **11**, 324). He says: "Some analyses I made, many years since, of sheathing copper which had long resisted the action of sea water proved the presence of one ten-thousandth part of silver. It was found that even this small portion of silver sensibly modified the chemical relations of the metals, and observations had indicated that the quality for sheathing was improved. Copper of this kind is frequently met with in commerce, and is derived from the Chilian ores of copper, which, although argentiferous, do not yield enough silver to render its separation economical.

"An occasion offered for again examining this subject, when the argentiferous native copper of Lake Superior was first refined and rolled by the Revere Copper Co., more than five years since, and the results have lately been obtained. Four suits of sheathing, for large merchant vessels, formed the subjects for observations, the metal being of uniform composition, as determined by assay of the clipping from many sheets. Two thousand parts of the alloy contained four parts of pure silver, or the standard ton of this country contained four pounds of silver (0.20 per cent.).

"A *proximate* analysis of this metal was also made, and it proved to be pure copper throughout, the mass of which, an alloy of silver and copper, was evenly distributed so as to form either a mixture or a compound alloy, in which one part of the copper is truly combined with the silver, and the other and larger part simply combines with the alloy. This is a very common constitution of alloys, in which two metals exist without any metalloid occurring to disturb the simplicity of the union, and always indicates a careful purification of the metals.

"It was assumed as probable that the silver alloy would close the pores of the copper, which takes place with a tin alloy in bronze, and, in a mechanical way, confers durability. If, however, corrosion should take place, it was in accordance with observed cases that the silver alloy would act as a negative element, and the copper alone would be removed. How erroneous these inferences proved will be seen in the detail of the results.

"The Chicora was coppered January 9, 1847, taking 7392 pounds of metal, which was fastened by bronze nails. She was employed in trade to China, and wore her copper so rapidly that it was removed in March, 1849, 2628 pounds only remaining. In this case the sheets, after the usual operations, had been consolidated by 'cold-rolling.'

"The Serampore was coppered January 18, 1847, requiring 8447 pounds of 'cold-rolled' metal, secured by bronze nails. She sailed to China and home *via* Cape of Good Hope, and to the Pacific and home *via* Cape Horn, requiring new copper in March, 1850. The weight of the remaining copper was not ascertained.

"The Hamilton was coppered October 22, 1847, requiring 7706 pounds metal, secured by bronze nails. The sheets used were in the ordinary or annealed state. This vessel was employed in the India trade, and wore out her copper in August, 1849. The weight of the copper remaining was 3086 pounds.

"The Carthage was coppered November 26, 1847, requiring 8727 pounds 'cold-rolled' metal, fastened by bronze nails. She was employed in the India trade, and her sheathing was destroyed in August, 1849. The copper remaining weighed 5810 pounds.

"Omitting the case of the Serampore, where the corrosion cannot be determined by weight, we have the loss in every one hundred parts of metal, for the time of duration, thus: The Chicora, twenty-seven months, lost 64.45 per 100; the Hamilton, twenty-three months, lost 59.95 per 100; the Carthage, twenty-one months, lost 33.45 per 100.

"Allowing the same rate of corrosion, and taking the time as twenty-seven months for each: The Chicora lost 64.45 in 100; the Hamilton lost 70.38 in 100; the Carthage lost 43.00 in 100.

"In the cases of the Hamilton and Carthage we perceive the influence of the different processes of manufacturing the sheets on the durability of the copper. By the operation of 'cold-rolling' the surfaces of the sheets are rendered very compact, and in any corroding solution they bear a negative relation to the metal in the same sheets between these surfaces. Such copper is also always strongly negative to annealed copper in acid solutions until the hardened surfaces are removed; it then loses this relation. The Hamilton exhibits the greatest effect of sea-water action on the annealed alloy, while in the Carthage the protecting influence of the hardening surface was exerted nearly to the time her copper was removed. These observations establish the fact of the rapid corrosion of an alloy thus constituted, and show its entire unfitness for sheathing purposes.

"The average duration of copper sheathing decreases slightly as the requirement of greater speed in sailing is more urgent. Taking one hundred merchant ships, sailing on different oceans, the average duration now on American ships is three years.

"On the point of the *kind* of corrosion following the exposure of the alloy to sea water and air, the information obtained of these trials is of a definite character. Part of the sheets remaining, and an ingot of the copper from smelting a large quantity, were assayed, and the results showed that the same proportion only of silver remained as was originally contained in the alloy. The silver, therefore, by taking the negative state in the mass of the metal alloy hastened its destruction, while its own form and condition were such that it separated as the copper was corroded."

In this connection I made the following analyses. In these analyses I designate the copper from the rudder of the Juniata as "rudder copper," that taken from the Juniata after corrosion as "old Juniata copper," that taken off from the Brooklyn, in order to put on her present suit, as "Brooklyn copper," and the new sheet from the New York storehouse as "new Juniata copper."

In the analyses of the coppers, I have followed the methods given by Andrew A. Blair, chemist to the United States Board for Testing Metals, which appear as an appendix to Ex. Doc. 98 of the Forty-fifth Congress, Second Session; and I have also employed the method of W. Hampe, given in *Zeitschrift für Analytische Chemie*, 176, 1874, and in Watts' *Dictionary of Chemistry*, Vol. VIII, Part I. The methods have sometimes been modified in a measure, to accommodate them to the appliances at hand. In the table, the "rudder copper" is No. 1; the "Brooklyn," No. 2; the "new Juniata," No. 3, and the "old Juniata," No. 4. The results given are the mean of a number of determinations:

	1.	2.	3.	4.
Copper,	99.428	99.225	98.426	98.509 per cent.
Silver,	.125	.085	.005	.010
Arsenic,	trace.	none.	.135	.159
Antimony,	none.	none.	.008	.005
Lead,	.010	.080	.178	.152
Iron,	.183	.252	.650	.580
Nickel,	none.	none.	.050	.010
Zinc,	none.	none.	.170	.150
Bismuth,	.005	.003	.012	.015
Oxygen,	.155	.185	.280	.235
	99.906	99.830	99.914	99.825

For comparison with these, I have sought to obtain analyses of different American coppers from the principal sources, in order that we might determine what would be termed "pure copper" in commerce here, but I have been unable, as yet, to obtain such, so I give (1) an analysis of a "refined copper," from Oker, made by Hampe, and reported in Fresenius' *Quantitativen Chemischen Analyse*, **2,** 527; 1882; (2) an analysis of a "refined copper" from Colorado, made by T. Egleston, Ph. D., and given in *Trans. of American Institute of Mining Engineers* for October, 1882; (3) an analysis of "ingot Lake Superior copper," Andrew A. Blair, *loc. cit.* 295.

	1.	2.	3.
Copper,	99.325	99.705	99.420 per cent.
Silver,	0.072	0.135	0.014
Gold,	0.0001	...	...
Arsenic,	0.130	0.091	none.
Antimony,	0.095	...	none.
Bismuth,	0.052	...	none.
Lead,	0.061	none.	trace.
*Iron,	0.063	0.031	0.013
Cobalt,	0.012	...	...
Nickel,	0.064	...	...
Sulphur,	0.001	trace.	...
Oxygen,	0.1166	...	...
Tellurium,	...	0.083	...
Zinc and nickel,	...	0.024	...
Suboxide of copper,	...	...	0.537
Carbon,	...	...	0.041
	99.9917	100.069	100.025

The Juniata copper, then, is not so pure as the rudder copper or the Brooklyn copper, or the copper last cited. The excess of silver in the rudder and Brooklyn coppers may at first excite remark, but we must remember that both of these coppers had been exposed to sea water for a very long time, and that sea water contains chloride of silver in solution, and that silver will be deposited upon copper under these circumstances. Mulder, in his *Die Silber-Probirmethode*, 27, states that chloride of silver is soluble in solutions of all the metallic chlorides which are soluble in water. Watts' *Dictionary of Chemistry*, **5**, 271, states that silver has been detected in sea water, and refers to *Ann. Ch. Phys.* [3] **27**, 129, which I have not been able to consult, and T. Sterry Hunt, *Chem. and Geol. Essays*, 231, repeats this statement. To test it, I placed some freshly precipitated and

*In examining the copper for iron, I deemed it important to test the nitric acid used, although it was bought, as chemically pure, through Desaga, of E. Merck, of Darmstadt. The first bottle examined was but partially full, and had been standing for some time in strong sunlight, and was evolving nitrous fumes, notwithstanding that the glass was of a dark green color. Analysis showed it to contain .00135 gram of iron in 100 cm. Another full bottle of the same lot, which had been standing in the dark, was tested, and was found to be free from iron. This last was used in the analyses.

washed chloride of silver in Severn water and inserted a strip of copper. In twenty-four hours a decided coating of silver was deposited on the copper.

The amount of silver present in the Juniata coppers seems, however, too small to have been the source of this trouble, and of the other substances found, the oxygen appears the one most likely to have been the cause of the trouble. It should be said that the darker, spotted portions of the new sheets were taken for analysis, and that on especially removing the surface from some of these spots by the aid of a bright steel file-scraper, I found it to consist of a film of oxide free from sulphide. But as from the first my attention and that of others had been called to this unusual feature in the copper, and as these spots closely resembled the corroded spots in form, it seemed proper to select these portions. I am not, however, assured that the oxide originally existed in the copper.

The following experiments were made to ascertain if corrosion would take place between copper and copper oxide in the presence of the materials in the Wallabout. Heavy, cold-drawn copper wire was cut into pieces. Each piece was then bent, and one end was heated in the flame until it was coated with oxide. The strips were then immersed in the solutions or buried in the mud, as given in the table below. We then had an electro-chemical couple with copper and oxide of copper. In the experiments cited below, No. 5 and No. 6 were the most satisfactory as regards the cleanliness of the copper after removal from the solution and washing:

Substance Used.	Loss.		Remarks.
1. Copper and Williamsburgh sewage.	1.42	per cent.	Liquid alkaline—contained coal tar.
2. Copper oxidized and Williamsburgh sewage	1.45	"	Liquid alkaline—contained coal tar—copper pitted.
3. Copper and Brooklyn sewage.........	3.42	"	Liquid faintly alkaline.
4. Copper oxidized and Brooklyn sewage..............................	2.99	"	Liquid faintly alkaline—copper pitted.
5. Copper and mud from under shears and Severn water......................	7.24	"	Liquid faintly alkaline—no pitting.
6. Copper oxidized and mud from under shears and Severn water...	14.64	"	Liquid faintly alkaline—copper badly pitted.
7. Copper and mud from Ordnance Dock and Severn water..............	4.06	"	Liquid alkaline—no pitting.
8. Copper oxidized and mud from Ordnance Dock and Severn water....	3.06	"	Liquid alkaline—copper faintly pitted.

As in these cases the solutions were all slightly alkaline, I repeated the experiments with Severn-River water, and with common-salt solutions, and in each case the copper was corroded. In addition, I connected my couple with a galvanometer and got a marked deflection of the needle. Hence there can be no doubt that electro-chemical action can go on between copper and copper oxide in sea water. This view is supported by the fact that all authorities are agreed that the corrosion of pure copper by pure sea water cannot take place in the absence of air. This air supplies oxygen, and the first step in the process of corrosion is one of oxidation. If, then, the copper be oxidized when immersed, the process is facilitated.

5. That it was caused by the adhesion of coal tar. In the examination of the Juniata, no coal tar was observed in contact with the corroded spots, though small amounts were noticed elsewhere, the copper at those points being sound. In the experiments last cited, when coal tar was present it adhered to the copper so firmly that it was difficult to remove it, and it formed a strongly adherent varnish or lacquer which seemed to protect the copper from corrosion.

6. That it is due to physical or chemical differences in different parts of the copper which were caused by the method of manufacture. From the consideration of all the circumstances, and especially of the facts that the copper is found to be *spotted* with oxide; that these spots are irregularly distributed over the plates; that they generally agree in configuration and size with the corroded spots, and that the copper at the corroded spots appears laminated, I am led to conclude that this theory is the more probable one, and that the imperfections result from blister-holes in the copper and the incomplete removal of the scale.

We have found that in the existence of these spots of scale or oxide we have a condition which is favorable to the commencement of the corrosion. Why does it continue?

If we examine one of the corroded spots from which the surface has been removed, we find that the remaining surface is roughened. Now, such a surface is more readily attacked than a polished surface. This latter is a well-known fact in connection with the "rusting" or corrosion of metals, and it is for this reason largely that metal articles are polished. But it seems to me that there is an additional reason for action at this point. In the *Proc. Nav. Inst.* **8**, 502 I have shown that annealed steel is much more soluble in sea water than "tempered" or hardened steel, and that when in contact the soft metal is rapidly

corroded. I have recently been confirmed in the truth of my observations by the investigation of M. Gruner in *Comptes Rendus*, **96**, 195. I am inclined to the opinion that the same holds true of copper of varying hardness, and I find support for my opinion in the statement of A. A. Hayes.* I believe that the copper beneath the spots of scale is softer than that about it, and furnishes the differences necessary for this action.

My theory to account for the existence of these differences and for the formation of the spots is as follows: I assume that an unsound cake of copper is taken for rolling which contains cavities like those seen in the ingot from Pope & Cole. When this is rolled into a bar, the cavities will be extended in the direction of the length of the bar. When the pieces of bar are afterwards rolled into sheets, these cavities will also be extended in the direction of the width of the sheet. These changes in form would of course be irregular, and would tend to produce such shapes as were seen on the copper. These cavities would necessarily contain gas, and copper is a very excellent conductor of heat, while gases are as a rule very poor conductors. Then, when the whole is heated and allowed to cool, the space about the cavity would be longer in cooling than the remainder, and, as a consequence, more scale would be formed at that point than elsewhere, and might adhere more firmly, or its formation might continue after the scaling process was considered complete. This layer of oxide and cushion of gas would then prevent the copper at this point from becoming as hard, through rolling, as over the remainder of the surface. The fact that the copper appears slightly laminated at some of the corroded spots seems to substantiate this theory. It may be objected that an enclosed gas at the high temperature of the operation would exert pressure sufficient to burst the envelope, but we must remember that the cavities were formed when the gas was at the temperature of molten copper.

In conclusion, I would state that in my opinion the corrosion of the Juniata's copper was due principally to the presence of spots of oxide of copper on the surface of the plates at the time they were put on, and I would recommend in the future the use of a pure copper, care in the production of sound cakes, and careful removal of the scale.

* *Loc. cit.*

U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

A PRACTICAL METHOD OF ARRIVING AT THE NUMBER, SIZE, TYPE, RIG, AND COST OF THE VESSELS OF WHICH THE U. S. NAVY SHOULD CONSIST IN TIME OF PEACE.*

By Lieutenant-Commander F. M. Barber, U. S. N.

There is but little doubt of the fact that it is utterly impossible to-day to reconcile the ideas of different naval officers as to the size, rig, number, or types of vessels which we require, and that there is really no safe rule for a Congressional committee to be guided by in recommending the adoption of any type of ships, or the appropriation of money to pay for them.

The first Advisory Board recommended a large number of ships, the plans and calculations of which were scarcely worked out before it ruined itself by a minority report. The second Advisory Board proposed ships differing entirely from those recommended by either the majority or minority of the first board; and, finally, the third (or Walker Board so-called) has recommended ships differing in most features from those recommended by the second board; and, lastly, Mr. Whitney has procured some entirely new plans from abroad. These differences naturally arise: 1st. From the immense variety of ideas that modern mechanical ingenuity admits of being made practical; 2d. From the confusion arising from the rapid advance in ordnance, steam engineering and ship construction; and 3d. From the variety of duties that a single man-of-war must be considered capable of discharging. Such difficulties will always arise until the subject of a new Navy is considered by a different body of men, and from a different standpoint.

* This paper was received too late to admit of discussion; but, as it expresses the opinion of a member of the present Advisory Board, its publication without discussion has been recommended by the Board of Control.—Editing Committee.

Happily, within the last four years a number of very troublesome topics pertaining to the Navy have been reasonably well settled.

1. It is generally conceded that, for all purposes, steel and composite-built ships are the best.

2. The Gun Foundry Board has made a definite report on the subject of guns.

3. The Fortification Board has made a definite report on the subject of coast-defense vessels heavily plated with steel. The types of these vessels have been carefully worked out by competent people, and also the types of some small coast-defense gunboats, and gun and torpedo boats.

This much, then, of the road is clear, and coast-defense vessels could be built *ad libitum* on plans already thought out, and no man could justly say that the money was ill-spent, for no country in the world is so defenseless as ours; but, in order that a definite policy of expenditure for a *sea*going Navy should be arrived at, a competent board is absolutely necessary. It is not a mere matter of choice whether we shall have a 3000-ton ship or full sail power, or two-thirds sail power, or no sail power, or a superstructure deck, or a poop and forecastle, or forty ironclads, or four ironclads, or turret ships or barbette ships, or dispatch boats or gunboats. These matters are important, it is true, but they are entirely secondary to, and many of them would be utterly wiped out by, the more important matters which affect the very existence of the seagoing Navy, and which should be thoroughly discussed by a competent board before the secondary matters are thought of.

All the boards that have been heretofore organized for recommending and designing ships have been either wrongly constituted, or else so hampered by the law creating them as to be worthless. These boards have been either composed of officers alone, or of officers and civilian experts. Both plans are wrong. Any board, to be efficient, should possess three qualities: 1st. It should not be too large (this was one trouble with the first Advisory Board); 2d. It should consist (with its president) of an odd number of members; 3d. It should be composed of men capable of discussing among themselves every subject that the duties of the board may give rise to.

Officers alone should not constitute a board: they are all (like myself) professionally anxious for a larger Navy than Congress and the country would deem necessary. Civilian shipbuilding and engineering experts are not necessary: there is better talent for *men-*

of-war-designing among our constructors and engineers in the Navy than can be found anywhere else in the United States. No civilian in the United States has ever built a modern man-of-war or its engine on his own design: these things cannot be originated or invented by anybody in a moment; and our officers have devoted more study to foreign plans than civilians have. The civilian element that *is* required on the board is that which is most readily found in Congress—men who by their habit of thought and national views are capable of studying the first and most important question which will come before this board—viz.: the political and geographical position of the United States with reference to the other nations of the world; its commerce, its future, and the corresponding seagoing Navy which is requisite. A second and most important duty of these members would be to so shape the final conclusions of the board that a sensible bill could be drawn up (based upon the report of the board to the President) for presentation to Congress, in which that body could find something tangible and definite to discuss. A third duty of these members would be to present this bill to both Houses of Congress and *defend it.*

This board should consist of a president and eight members, to be composed as follows: One member of the Senate Naval Committee of long standing, one member of the House Naval Committee of long standing, one Captain in the Navy, one Lieutenant-Commander or Lieutenant, one Naval Constructor, one Assistant Naval Constructor, one Chief Engineer, one Past-Assistant or Assistant Engineer. The president of the board to be the Secretary or Assistant Secretary of the Navy, and the secretary of the board to be an Assistant Naval Constructor. This arrangement would combine experience, practical knowledge and theoretical knowledge of all subjects which would come within the province of the board.

Should such a board be organized, the following results are quite possible:

The first duty would be to study, as I have indicated, the position of the United States and its commerce, present and future, in different parts of the world, together with the number of its citizens residing and in business abroad, and the amount of protection deemed necessary to be within easy call at any time. This would lead to a close study of the number of miles of coast that come within the jurisdiction of our several squadrons and the relative importance of our interests there; also to an estimate of the powers of offense and defense of the countries owning the territory. These considerations, together with

the peculiar conditions of each locality, its degree of civilization, belligerency, etc., would fix approximately the number of ships required; and to this number at least 25 per cent. must be added to provide for relief vessels going to and coming from home.

Having reached this approximation, the attention of the board would next be called to the number of men available to man these ships. We have but 8000 men in the Navy, and it would be a matter of serious consideration for the legislative members of the board whether it would be wise to go before Congress and advocate an increase of that number. This matter is seldom discussed, and yet it lies at the bottom of the whole fabric of a peace Navy. Of what use is it to advocate the building of 40 large ironclads, as some do, when a dozen of them would take all the men we have and not leave a man for anything else? I doubt, however, if any one in Congress would advocate a much greater number of men than 8000. Supposing that the number be limited to 8000, our naval coat must be cut according to this cloth, and, before utilizing it, there must be deducted the total number necessary at our numerous navy yards for taking care of laid-up coast-defense vessels and receiving ships, running tugs and steam launches, etc., etc. With the remainder, whatever it may be, an estimate must be made of the size of crews that can be allotted to the vessels for foreign service, the number of which has been previously approximately estimated.

In spite of all the labor saving appliances that ever have been invented, the crew of every man-of-war should be relatively large, to supply landing parties—a matter of growing importance in naval warfare. Hence, taking all these things into consideration, if the majority of this board were men of my way of thinking, the greater number of the vessels required by the United States in foreign waters would be small (from 400 to 1000 tons), in order to secure the greatest good by the greatest dispersion of our small total number of men. This dispersion is absolutely necessary to secure promptitude in affording that show of physical force at any point in a station which is so necessary to give confidence to the people requiring protection, and so essential to inspire respect among parties liable to give offense. It carries with it the necessity of having vessels in as many different ports as possible at the same time; that they should always be, so far as possible, within telegraphic communication with the admiral; that when changing stations the utmost expedition should be used from port to port; for a man-of-war out of telegraphic communication is useless in time of peace.

Allowing 100 men to each vessel, which is a very small number, it can readily be seen that in order to have seven or eight very small vessels actually on each of our stations, with their reliefs going and coming, we shall only have enough men left for seven or eight vessels carrying 300 men each, which would only give *one* of these vessels to a squadron. If this train of reasoning is correct, or only approximately correct, does it not at once simplify a great number of these minor questions of type, rig, etc., which are now so constantly thrust to the front?

If we can only have eight small vessels and one large one on the Pacific Coast, or in China, for example, can there be any question in this day but that the large one ought to be an ironclad? And, if the little ones cannot carry coal enough to steam across the Atlantic Ocean, is there any question but that they ought to have large sail power? This latter will diminish their steaming speed, to be sure, but not their general usefulness, and if the large vessel by not having sail power could carry seventy-five tons more coal or an inch more armor and make a knot more speed, ought she to be obliged to have it? And if the larger vessel, by reason of her excellent fighting qualities, has limited accommodations (as is sure to be the case), would it not be reasonable and economical to have a dispatch boat for a flagship?

It would appear that many of these other difficulties that we are now struggling with could be made to disappear by the same method of reasoning. By the system that I have adopted we do away with any discussion of relative merits, of Boston type or Chicago type, etc., etc., because we would have neither. If the board should decide that we wanted these types, and were willing to forego the obvious advantage of great dispersion of our small total of 8000 men, then the small classes of vessels would largely disappear and there would be no use in wasting breath in discussing *their* types.

Since the United States is eminently a nation of peace, its defenses should be made invulnerable, for its powers of offense will never be great, except possibly towards the end of a long war, if we should ever be so unfortunate as to become involved in one; therefore, the question of a seagoing Navy for a general war should be kept almost entirely separate from that of a peace Navy. Of course, such ships as are built at *any time* should have good guns and good engines; but the advance of modern science in every direction is so great, that it is simply impossible to construct a ship that might be able to meet all the contingencies of a war with a nation like England, for example.

No nation now-a-days, not even England, could protect its commerce in a great war, and it will probably have no occasion to do so after the first two weeks, as few steamers now-a-days are out from port longer than that, and no insurance could be obtained on cargoes under belligerent flags: ownership would be transferred to neutral flags at once; and, in any event, the very best commerce protector or commerce destroyer is a first-class merchant steamer bought out of hand, filled with Hotchkiss rapid-firing guns, and sent to sea full of coal.

General usefulness in *time of war*, for a man-of-war or any other vessel, is a question of coal-piles and not of canvas, and this question of coal-piles will be one of the most serious that our hypothetical board would have to consider; not that it would have any effect on the rig of our vessels, for no man-of-war would dare to go to sea in time of war under sail with any expectation of reaching port, let alone of capturing or protecting anything; but it would be the board's duty in its report to make the country alive to the importance of this vital point, and, if we are to have no coal-piles, to outline to Congress what our men-of-war must be almost obliged to do if they are away from home when a war breaks out and coal is still contraband of war —viz.: *Stay in port*, and in case of a long war dismantle ships and send crew and officers home.

Having fixed approximately the number and size of ships, the total cost could be estimated with a reasonable degree of precision, and an annual appropriation calculated which would finish all the ships at the end of a determined number of years; and in this way let Congress see what it has before it, in the same logical manner as has been done by the Gun Foundry Board and the Fortification Board.

As a conclusion, the board would be called upon to investigate how these ships are to be built and where, by contract or in the navy yards, or both; secondly, if all the navy yards are not to be employed, recommend what should be done with the unemployed ones; and lastly, if it is deemed wise that the unemployed yards be not abolished, make some suggestion in the direction of an appropriation for their maintenance which will be separate and distinct from the Navy Appropiation Bill proper, so that there may be a final ending of the continual reproach to the naval administration "that the Navy consumes annually fifteen millions of dollars and has not a ship to show for it." How can we have any ships when it takes fifteen millions for one gigantic organization merely to "mark time"?

NOTES ON THE LITERATURE OF EXPLOSIVES.*

By Charles E. Munroe.

The *Trans. Tech. Soc. of the Pacific Coast*, **2**, 267; 1885, contains a paper by Fred. H. Jenssen on "Dynamite Catastrophes," in which he criticises adversely the theory advanced by L. J. Le Conte† to account for their occurrence. Mr. Le Conte states that 90 per cent. of all the explosions on the Pacific Coast since 1879 occurred during violent desiccating north-wind storms, and that electricity has been the exciting cause in all these cases. Admitting the existence of a dry north wind at the time of the several explosions, it is a fact that the survivors of two of them give reasons for their occurrence which are at variance with Mr. Le Conte's theory.

The explosion at Stege on March 25, 1882, occurred during the manufacture of black powder, called Vulcan B. B. This powder is composed of sodium nitrate, sulphur and charcoal, which are mixed in a perfectly wet state. During this mixing process the superintendent called the foreman and told him that the mixture was not wet enough, and that he should put more water in the basin, as it had been demonstrated by experiment that where the mixture fell below a specified percentage of moisture it would ignite by the friction of the machinery. A few moments after the departure of the superintendent, and before the water was added, the explosion took place.

The explosion at the Giant Powder Works, January 21, 1883, was caused by sparks blown from a wheelbarrow of hot ashes into a box of dynamite.

As to Le Conte's second conclusion—that a dust explosion precedes

* As it is proposed to continue these Notes from time to time, authors, publishers and manufacturers will do the writer a favor by sending him copies of their papers, publications, or trade circulars.

† Proc. Nav. Inst. **12**, 181; 1886.

that of the dynamite—Jenssen states that in the nitroglycerin department of the dynamite works there is no dust of an inflammable nature; nevertheless a number of explosions have taken place in that department, especially during the first years of the manufacture of dynamite, but now are of rare occurrence. In all the dynamite explosions named, with the single exception of that at the Hercules Powder Works, September 29, 1883, no explosion started in the mixing house, and not one of them can be traced to a dust explosion.

In regard to the danger from lightning, it is admitted that a stroke of lightning will explode dynamite, but small sparks of electricity will not do so. The Swiss committee on the physical qualities of dynamite reported,* some sixteen years ago, that " thunderstorms and lightning involve no special danger to dynamite. As far as conclusions can be drawn from small experiments with heavy discharges of electricity, dynamite, unless well confined, will only burn if struck by lightning. But if well confined, and if the temperature produced by the lightning be high enough, an explosion may possibly take place."

Apropos of the danger of nitroglycerin being exploded by the heat of the sun, the author asserts that *pure* neutralized nitroglycerin or dynamite will stand 170° F. for some time before it decomposes. Long experience has demonstrated that dynamite cartridges in boxes can sustain a temperature of 128° F. for years. But when the dynamite without covering has been exposed for a considerable length of time (varying with the quality) to the sun's rays, on touching it with blue litmus strips the paper turns red.

On January 29, 1881, a man by the name of Lasker was killed in McKean County, Pa., by the explosion of a lot of nitroglycerin which was being thawed by the agent of Roberts & Co. for the purpose of "shooting" an oil well. Suit was brought to recover damages for the loss of Lasker, and the official report of the trial, which was continued from court to court, and which contains considerable expert testimony, is recently come to hand under the title Roberts *vs.* Lasker, in the Supreme Court of Pennsylvania, Eastern District, Paper Book of Plaintiff in Error.

From this we learn that nitroglycerin was used in the liquid state in torpedoes for "shooting" oil wells. The nitroglycerin torpedo consists of a tin shell from three to five inches in diameter, and from five to

* Trauzl Nitrilverbindungen, Wien, 1870.

twenty feet in length, according to the quantity of glycerin which the well-owner desires exploded. All the shells are taken to the wells empty—the longer ones in sections, which are there put together as they are lowered into the well. The nitroglycerin is taken to the wells in square tin cans holding about six quarts each, and weighing when filled about twenty pounds each. This charge does not fill the cans completely, so water is poured in the space above to assist in the preservation of the nitroglycerin. After the tin shell is placed in the top of the well it is filled with nitroglycerin and tightly closed with a cover, in the middle of which is a percussion cap. When thus prepared the torpedo is lowered to the bottom of the well (a distance usually of about 1500 feet) by means of a wire. A perforated iron weight is then strung upon the wire, and, when the torpedo is properly placed, it is exploded by allowing the iron weight to drop from the surface of the ground and fall upon the cap.

The object of "shooting" the well is to remove the dense paraffins or other solids which obstruct the flow of the oil, and to shake the oil sandstone; and nitroglycerin has been found most efficient for this purpose. The right to use this explosive is, however, secured to Roberts & Co. by letters-patent, and has proved a most profitable monopoly, their profits at the time of the trial being fixed at three thousand dollars a day. Naturally their rights were infringed or evaded in many cases, and a class of men known as "moonlighters" sprung up in the oil regions, who exploded torpedoes in the oil wells at night. Others, however, simply placed a large torpedo in the well, and then employed Roberts & Co. to explode a small torpedo above it. The torpedo thus surreptitiously inserted in the well is known as a "setter," and it is believed by those who practise this that they successfully evade the Roberts patent.

As the driving of wells is carried on at all seasons, it frequently happens that the nitroglycerin comes on the ground in a frozen state. That was the state of the nitroglycerin in this case, and it was sought to thaw it by placing the cans (seven of them) in an oil barrel filled with water and passing steam through the water. Four of the cans were placed at the bottom, and the remaining three on top of these. The corks were out of the cans, so that the explosive was surrounded by water. The oil barrel rested on trodden-down snow, and the steam was brought seventy-five feet through a rubber hose stretched over the snow. There were fifty pounds' pressure in the boiler, and the throttle was turned about one-fourth. It seems undetermined

whether there was or was not an iron nozzle to the hose, but the end of the hose reached to within four inches of the bottom of the barrel. The hose remained in the barrel for about one-half hour, when it was taken out, as the water was thought warm enough. After another half hour it was put in again, and had been in but a short time when the agent walked to the barrel and found the water perfectly quiet, and so hot he could but just bear his hand in it (about 115°–120° F.). He then turned away, and had gone but about fifty feet, and had been away but about twenty seconds, when the explosion occurred. The agent was uninjured, but Lasker, who was in the engine-house, about six feet off, was killed. The defendant sought to show that a "setter" had been put in the well, and that the nitroglycerin for it had been thawed during the night in this same barrel, and that some of the liquid had been spilled in the barrel, but the court refused to admit the testimony. The plaintiff sought to show that the explosion was induced by the agitation set up in the barrel by the escaping steam, or by the energy developed by the steam impinging on the cans, but the real cause was left in doubt.

In the course of his testimony W. B. Roberts stated that he had made nitroglycerin since August, 1866, and that during that time he had made about one million pounds and handled one and a half million pounds. He first became acquainted with it after the explosion in Greenwich street, New York. The remainder of this had been buried by the authorities near Eighty-third street. Dr. Roberts went there, dug it up, and got about one hundred pounds, which he sent to Titusville, and used in the oil wells. The nitroglycerin now used is transported about the country, over the roughest roads, in spring wagons, the boxes being partitioned into squares the size of the cans, and upholstered with leather on the sides and bottom. The empty cans are destroyed by piling them on a brush heap, laying a train of nitroglycerin under it and setting fire to the whole. When explosion takes place at one point it is immediately communicated to the whole. No method of cleansing has yet been found which is effectual.

As giving some idea of the extent of the nitroglycerin industry in this country, we note that Mr. W. N. Hill stated in his testimony that, as chemist to the Repauno Chemical Company, he was, at the time (1882), making from fifty to one hundred thousand pounds of nitroglycerin a month. Sometimes he had made as many as ten runs, of six to seven hundred pounds each, at one time.

In the course of the trial various books were offered in evidence, and the court ruled that they might be read to the court to explain the scientific names and terms used, but not to the jury. The rule seemed to be that books written upon inductive sciences were not admissible, while those on the exact sciences could be offered. He believed the science of chemistry an exact science, and not an inductive one in a philosophical sense of the term, but the scientific knowledge of nitroglycerin might not be so exact as would authorize the reading of authorities in evidence to the jury. Some of these books might be evidence—for example, those which treated of the whole system of chemistry. He had grave doubts as to the articles written in the chemical journals being evidence, but they could be read to the court as law-books.

W. Poetsch (*Dingl. polyt. J.* **255**, 216) suggests "Recovering the Waste Acids from Nitroglycerol Works" by the following method: On heating the waste acids, consisting of sulphuric and nitric acids and organic nitro-compounds, at 105°, decomposition of the nitro-compounds ensues, oxidation to carbon dioxide taking place at the expense of the nitric acid which is present. During the reaction enough heat is liberated to volatilize the remaining portion of undecomposed nitric acid and the lower oxides of nitrogen produced, pure sulphuric acid being left in the residue. The author uses a closed vessel of stone or lead, having a perforated bottom 50 cm. above the bottom. The upper space is filled with stones or broken stoneware, and heated by hot air. The waste acid is introduced in a thin stream through a funnel fitted into the cover of the vessel, and, passing over the hot stones, is decomposed. The nitrogenous vapors are led through an earthenware pipe to a cooling worm, and collected in Wolff's bottles, air being introduced to oxidize the gases to nitric acid. The denitrated sulphuric acid flows through the perforated bottom, and is run into receiving tanks. (Abstr. *Jour. Chem. Soc.* May, 1885, p. 619.)

After more than seven years of investigation and experiment, the English royal commission appointed to inquire into accidents in mines has presented its final report, which was issued April 10, 1886, in the form of a blue-book of one hundred and ten pages. The delay is accounted for by the long and difficult quest on which the commissioners were sent. They were to report not only on the causes of

mining accidents, but also on the "possible means of preventing their recurrence, or limiting their disastrous consequences." Not much is recommended in the way of mere legislative changes, but the scientific recommendations are most interesting and important. For example: With reference to the difficult question of the best method of firing shots in mines, they state that "electrical exploding appliances present very important advantages from the point of view of safety over any kind of fuse which has to be ignited by the application of flame to its exposed extremity, as the firing of shots by their means is not only accomplished out of contact with air, but is also under most complete control up to the moment of firing. Their simplicity and certainty of action have been much increased of late years, while their cost has been greatly reduced, and but little instruction is now needed to ensure their efficient employment by persons of average intelligence. The use of electrical arrangements for firing shots in mines, where the employment of powder for blasting is inadmissible, should be encouraged as much as possible."

Again, they state that "it has been shown that mines which have hitherto been considered free from fire-damp may have the air which passes through them vitiated to an extent corresponding to about two per cent. of its volume of marsh gas. The air in many such mines may probably never be entirely free from explosive gas; at all events, in the neighborhood of freshly cut faces of coal and in the return air-ways. It has been demonstrated in our experiments that when the atmosphere contains five to five and one-half per cent. of marsh gas, it becomes highly explosive. We have even obtained explosions which, though less violent, might be, nevertheless, destructive of life if they occurred on the large scale possible in a mine, when the air contained only four per cent. of marsh gas. It will thus be seen that air which would appear free from gas if tested in the ordinary way, may become, by the addition of only about two per cent. of marsh gas, capable of propagating flame and causing destruction, while the addition of about three per cent. converts it into a highly explosive mixture. Air which would appear quite free from gas if examined by a lamp flame, may become explosive when laden with fine, dry coal-dust.* Appliances now exist by which very small proportions of marsh gas in air may be readily detected, and which can be used for examining the atmosphere of a mine. With Liveing's indicator, gas present in the air can be estimated with

* Proc. Nav. Inst. **8**, 308 and 459; 1882.

sufficient accuracy for all practical purposes, even when the proportion is as low as one-quarter per cent."

The suggestion, first due to Mr. Galloway, that coal dust alone suspended in air might cause an explosion, is considered, and an account is given of some carefully devised experiments which rather tend to confirm this conclusion. The commissioners discuss with some detail the means of removing this dust, and devote a large section of the report to the question of the conditions under which blasting can be done in safety. Considerable space is devoted to safety lamps, and it is pointed out how great an influence the velocity of the air-currents in the air-passages of a mine has on the safety of a lamp. The commissioners are of the opinion that the older Davy, Clauny, or even Stephenson lamps, have in a great measure lost their value in consequence of the draughts of air from the free ventilation. A current of air of eight hundred feet per minute in an impure atmosphere may, in spite of the wire gauze, effect an explosion in any one of them. The electric lamp is perhaps the chief hope of the miner, though it does not, like the safety lamp, indicate the presence of gas. A rigid daily inspection is recommended. (*Science*, **7**, 389, 459; 1886.)

A. Witz (*Compt. Rend.* **100**, 1131–1132; 1885) finds that the theoretical temperatures and pressures produced by the explosion of mixtures of coal gas and air, as calculated from the heat of combustion of coal gas, are as follows:

	At constant volume. Temp.	Pres.	At constant pressure. Temp.	Pres.
1 vol. of gas + 6 vols. of air.....	2064°	8.6 atmos.	1596°	6.8 atmos.
1 " " + 10 " "	1514°	6.5 "	1169°	5.3 "

Any difference between the calculated and observed pressures must be attributed to the action of the walls of the explosion vessel, since Mallard and Chatelier have shown that carbon dioxide and water do not dissociate below 1800° and 2500° respectively in explosions.

Although explosions of coal gas with air are by no means infrequent, the compiler has found considerable difficulty in producing them at will on a laboratory scale by simply mixing air and gas. Acting on these suggestions of the part played by dust, he has placed a small quantity of lycopodium in the stout glass cylinders

used for the experiments. Gas was then allowed to flow in, the vessel covered and shaken. Then on applying a flame there was invariably a smart explosion.

G. Schelgel, in treating of the "Combustion of Hydrocarbons and their Oxides and Chlorides with Mixtures of Chlorine and Oxygen" (*Annalen*, **226**, 133–174), says it has been shown by Bötsch (Abstr. 1882, 456) that in the explosion of a mixture of hydrogen, oxygen and chlorine, water is formed only when the chlorine is present in amount insufficient to unite with the whole of the hydrogen. This result is important, inasmuch as it does not agree with the generally accepted rule that when several substances react simultaneously on one another, those reactions always occur in which the greatest amount of heat is developed. The author has extended these researches to the products of the explosion of mixtures of chlorine and oxygen with gaseous organic compounds. Experiments were made with excess both of chlorine and oxygen, with an excess of oxygen and an amount of chlorine insufficient to unite with all the hydrogen present, and finally with an excess of chlorine, but with an amount of chlorine insufficient to convert the whole of the carbon into carbon dioxide. The organic substances employed were methane, ethane, propane, butane, methyl ether, methyl chloride, ethyl chloride, acetylene and carbon monoxide. No results could be obtained with ethylene, as it unites with chlorine in the dark, and so prevents the formation of a uniform mixture for explosion. The following are the conclusions drawn from these experiments: 1. If a hydrocarbon be mixed with excess of chlorine and excess of oxygen, and the mixture exploded by the spark, the whole of the carbon is converted into carbon dioxide, and all the hydrogen into hydrochloric acid. Hydrogen does not unite with oxygen, nor chlorine with carbon. 2. If excess of oxygen be employed together with an amount of chlorine insufficient to combine with all the hydrogen present, the remainder of the hydrogen unites with the oxygen. 3. If with excess of chlorine the amount of oxygen is insufficient to convert all the carbon into carbon dioxide, there is then also formed carbon monoxide, the proportion of this latter increasing with the deficiency of oxygen. 4. If neither chlorine nor oxygen is present in sufficient quantity for complete combustion, carbon is separated. 5. The organic chlorides and oxides experimented with behaved in like manner to the hydrocarbons. (Abstr. *Jour. Chem Soc.* March, 1885, p. 214.)

F. Bellamy has studied the "Action of Some Metals on Mixtures of Acetylene and Air" (*Compt. Rend.* **100**, 1460–1461; 1885), with the following results: When a spiral of platinum or silver wire, heated just to incipient redness, is brought into a mixture of acetylene and air issuing from a modified Bunsen burner made of glass, the gaseous mixture at once detonates and inflames, but the spiral does not become incandescent. If, however, a copper spiral is treated in the same way, the wire becomes brilliantly incandescent, and eventually ignites the gaseous mixture. A spiral of iron wire behaves in a similar manner, but the incandescence is more difficult to obtain; if the spiral is too hot the gaseous mixture is at once ignited; if too cold, the wire remains non-luminous. Copper or iron wire does not become incandescent in a mixture of air and hydrogen.

Colonel Samuel Wetherill, Jr., has privately communicated to us an account of an explosion of metallic zinc. While engaged in 1854 in the manufacture of this metal, he devised a plan for utilizing the "blue powder," which is the finely divided metallic zinc deposited in the prolongation of the condenser. The process consisted in swedging the powder into blocks and placing these blocks one above another in a furnace, where they melted down and were run into spelter. The workman in charge proposed to facilitate the process by feeding the "powder" directly into the hot furnace and ramming it down with a bar. On trying this the first shovelful exploded, and with such violence that the man was blown from the top of the furnace and the blade of the shovel driven into the roof of the building.

In this connection we may state that with the "blue powder" furnished us from the Bethlehem Works we have easily obtained Schwarz's explosive reaction* with sulphur, though we were unable to get it with the powdered zinc of commerce, owing probably to its being superficially corroded.

We are indebted to Sir Frederick Abel for a copy of his address on "Accidental Explosions Produced by Non-Explosive Liquids," which was delivered before the Royal Institution of Great Britain, March 13, 1883, and which deals with the explosions produced by the petroleum oils. The lecturer cites numerous instances of explosions from this cause which have occurred both on land and at sea,

* Proc. Nav. Inst. **9**, 750; 1883.

details the attending circumstances and seeks to explain the cause. The most interesting to us are those on the Coquimbo, Cockatrice, Triumph and Doterel, which the lecturer now believes to have been caused by the petroleum spirits used in the xerotine siccative.*

In the *Proc. Am. Asso. Ad. Science*, **33**, 130; 1885, Charles E. Munroe proposes to use an electric motor and gun-cotton for illustrating experimentally the "Conversion of Mechanical Energy into Heat." For this purpose a Griscom electric motor is clamped to the base of a retort stand with its axis of revolution vertical, while a brass disk to which a flat cork is cemented is clamped on the end of the shaft. A shallow cavity is made in the cork, the bottom of a test tube is placed in the cavity, and the tube clamped in place. Gun-cotton is now rammed into the tube, the vessel corked, and the motor set in motion. With four Grove cells the friction of the cork on the tube generates sufficient heat, in half a minute, to fire the gun-cotton and blow the cork from the tube. With this apparatus the difference in the points of ignition of gun-cotton and gunpowder, and of gunpowder grains of different sizes and densities, besides many other experiments depending upon the generation of heat through friction, may be easily and simply shown.

In the study of the "Action of Primary Alcoholic Iodides on Silver Fulminate," by G. Calmels (*Compt. Rend.* **99**, 794–797), 25 grams of dried silver fulminate were heated with 25 grams of methyl iodide and 40 grams of ether in a sealed tube at 50° for twenty-four hours. The products were silver iodide, methyl carbylamine and β-nitroethylene. Ethyl iodide and the higher primary iodoparaffins react in a precisely similar manner.

$$CNAg:CAgNO_2 + 2MeI = 2AgI + CNMe + CH_2:CH.NO_2.$$

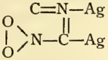
In this reaction silver fulminate is split up into two parts. In order, if possible, to obtain the intermediate compounds, $CNMe:CMeNO_2$, $CNEt:CEtNO_2$, 100 grams of methyl iodide mixed with 50 grams of ether were allowed to act on 50 grams of the dried fulminate at the ordinary temperature for four or five days, but the only products obtained were α-nitroethylene and methylcarbylamine. Ethyl iodide and its higher homologues behave in the same way.

The nitro-derivatives of the ethylene series are characterized by their power of existing in two modifications, the α-derivatives forming

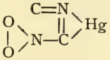
* Proc. Nav. Inst. **8**, 313 and 459, and 671; 1882.

colorless liquids soluble in ether and chloroform, whilst the β-derivatives are yellow, resinous solids insoluble in the same solvents. From their chemical behavior, it would seem that the former are the true nitro-derivatives, whilst the latter are oximido-derivatives.

From these results it follows that silver fulminate contains two dissymmetrical groups, each of which contains one atom of silver. One of these groups is silver cyanide, CNAg, whilst the other contains the sub-group $N\!\left\langle\begin{smallmatrix}O\\ |\\ O\end{smallmatrix}\right.$ and the second atom of silver, the latter being united with the second atom of carbon, which is in direct union with the nitrogen in the first group (this nitrogen acting as a pentad), and thus links the two groups together.



Silver fulminate.



Mercuric fulminate.

It is evident from this formula that the two metallic atoms in the silver fulminate have different functions, and this explains the non-existence of mixed fulminates of the alkali metals. The formula also explains generally the observed action of the halogens on the fulminates.

The fulminates are isocyanides or metallic carbylamines united by nitrogen to a bivalent residue of a metallic derivative of nitromethane, the metal attached to the nitro-group being any metal whatever. This function, which is peculiar to the carbylamines and does not appertain to the metallic nitriles (cyanides), may be termed the carbazilic function. The relation of the carbazilic type to the allied types is shown by the following formulas:—

C : N	CH_2.CH	C : N.Me	C : N.H
‖	\ //		‖
Me	N		CH_2.
Nitrile.	Metanitrile.	Carbylamine.	Carbazilic.

In the study of "Mercury Fulminate," L. Scholvien finds (*J. pr. Chem.* **30**, 91–92; 1885) that a solution containing sodium fulminate is formed by treating mercury fulminate suspended in water with sodium amalgam. When this solution is decomposed with dilute sulphuric acid, and shaken up with ether, the ethereal solution is found to contain two acids of the composition HCNO. The less

soluble of these crystallizes from ether in colorless needles, melting at 85°; it is soluble in lukewarm water, but is decomposed by boiling water. It forms a red, insoluble silver salt, a dark yellow mercuric salt, and light yellow lead salt; its solutions yield a deep red coloration with ferric chloride. Decomposed by hydrochloric acid it yields hydroxylamine. The more soluble isomeride may be crystallized from hot water, yields no coloration with ferric chloride, and forms no insoluble metallic salts. The aqueous solution of sodium fulminate gives a precipitate of silver fulminate with silver nitrate, which when treated with metallic chlorides and aniline hydrochloride forms double salts. It is decomposed by ethyl iodide, and with potassium sulphide yields an easily explosive compound.

Mercury fulminate and thiocarbamide yield carbon monoxide, mercuric sulphide, carbamide, a compound thiocarbamide and mercuric thiocynate.

A. Ehrenberg states (*Jour. prak. Chem.* **30**, 38–68; 1884) that Carstanjen and he have shown (Abstr. *Jour. Chem. Soc.* 816, 1882) that when mercury fulminate is decomposed with aqueous hydrochloric acid it yields its nitrogen as hydroxylamine hydrochloride. A further examination of this reaction has proved that both carbon monoxide and carbon dioxide are formed. The quantity of these compounds produced is but small, more especially when the decomposition is effected in the absence of air; and it appears that they owe their origin to the decomposition of formic acid, which the author has shown is produced by the action of aqueous hydrochloric acid on mercury fulminate. The reaction taking place may be represented as follows:

$$C_2HgN_2O_2 + 2HCl + 4H_2O = 2H.COOH + 2NH_4.OH + HgCl_2.$$

In the hope of realizing the following decomposition, and thus obtaining fulminic acid, $C_2HgN_2O_2 + 2HCl = HgCl_2 + C_2H_2N_2O_2$, the author passed dry hydrochloric gas into perfectly dry ether containing mercury fulminate in suspension. Mercuric chloride is produced, and the ether holds in solution a compound which undergoes spontaneous decomposition, most probably fulminic acid. If this ethereal solution is carefully added to aqueous ammonia, and the ethereal solution separated from the aqueous solution, the latter contains a yellow solid, which is sparingly soluble in cold water, but soluble in hot water, from which it may be obtained in yellowish

needles. The analysis of this compound shows it to be $C_3H_4N_4O_2$. It forms with silver nitrate a compound $(C_3H_4N_4O_2)$, $AgNO_3$, insoluble in cold water, and with an ammoniacal solution of copper oxide the compound $(C_3H_4N_4O_2)_2CuO(NH_3)_2$, which is obtained as a light-blue granular precipitate. From the ammoniacal solution from which the above compound was obtained the author has isolated an acid isomeric with fulminic acid, to which the name *isofulminuric acid* is given. It is easily soluble in water, from which it separates in ill-defined crystals; absolute alcohol dissolves it easily, and by cooling the hot saturated solution it is obtained as a white powder. With silver nitrate its aqueous solution gives a white amorphous precipitate of $C_3H_2N_3O_3Ag$, but yields no precipitate with ammoniacal solutions of copper oxide, lead acetate or mercuric chloride. The silver, ammonium and barium salts of this acid are described.

Together with this acid there is formed a small quantity of a compound more easily soluble in ether than isofulminuric acid, which is most probably the ammonium salt of amido-fulminuric acid, $C_3H(NH_2)N_3O_3.NH_4$.

Its aqueous solution gives precipitates with silver nitrate, lead acetate and copper sulphate, and a blood-red to brownish-red coloration with ferric chloride.

Thiocyanic acid reacts with mercury fulminate in a manner analogous to aqueous hydrochloric acid; mercuric thiocyanate, ammonium thiocyanate and carbon dioxide are produced, the production of the ammonium salts arising from the instability of hydroxylamine thiocyanate. The reaction may be represented thus:

$$C_2HgN_2O_2 + 4H.CNS + 2H_2O = 2CO_2 + Hg(CNS)_2 + 2NH_4.CNS.$$

The action of ammonium thiocyanate on mercury fulminate is analogous to the action of the chlorides of the alkali metals, but is more energetic; it may be expressed as follows:

$$2(C_2N_2O_2Hg) + 2H_2O + 2NH_4.CHS = \\ C_3H_2N_3O_3.NH_4 + Hg(CNS)_2 + HgO + CO_2 + 2NH_3.$$

A. Ehrenberg (*J. pr. Chem.* [2], **82,** 230–234) obtains "Sodium Fulminate," $C_2N_2O_2Na_2 + 2H_2O$, by the action of sodium amalgam on an aqueous solution of mercury fulminate, the solution obtained being evaporated over lime and sulphuric acid. It crystallizes in colorless, lustrous prisms, which explode with great violence when rubbed; when left for some time over sulphuric acid and lime the

crystals become white and opaque, the anhydrous salt being formed. If the aqueous solution is evaporated on the water-bath, it turns yellow, and finally brownish-red. Similar changes occur on exposure to air. When an aqueous solution is electrolyzed, the products are ammonium carbonate and cyanate, a brown, humus-like substance, carbon monoxide, nitrogen and nitrogen monoxide, and towards the end of the decomposition carbon dioxide and small quantities of hydrogen cyanide. Hydrogen peroxide converts it into ammonia, sodium carbonate, carbon dioxide and hydrogen cyanide.

The *double salt* $C_2N_2O_2Na_2C_2N_2O_2Hg + 4H_2O$ is obtained by the action on mercury fulminate of half the amount of sodium amalgam necessary for its complete decomposition, or by mixing solutions of the two component salts. It crystallizes in colorless plates, is readily soluble in water, and is less explosive than the mercury salt. When a small quantity of dilute acid is added to an aqueous solution, mercury fulminate is precipitated. Strong hydrochloric acid decomposes it; mercury, sodium and ammonium chlorides, and hydroxylamine hydrochloride being obtained. (Abstr. *Jour. Chem. Soc.* 1191, Dec., 1885.)

T. Sandmeyer (*Berich. Berl. Chem. Ges.* **11**, 1767; 1885) finds that "Ethyl Hypochlorite" is formed when gaseous hypochlorous oxide is passed into alcohol, or when concentrated aqueous hypochlorous acid is mixed with alcohol. The most convenient method of preparation is to pass chlorine into an ice-cold solution of soda as long as it is absorbed, and immediately add, with agitation, one-tenth the volume of alcohol. The ether very soon separates, and after washing and drying with calcium chloride may be distilled. *Ethyl hypochlorite*, ClOEt, is a yellow, mobile, and very volatile liquid. It distils at 36° (under 752 mm. pressure undecomposed), but if the vapor be superheated a violent explosion occurs. Powdered copper (precipitated from copper sulphate with zinc), when added to the cold liquid, causes a similar violent explosion. Carbon and sulphur do not act upon the liquid. Ether, benzene and chloroform do not act rapidly on this ethereal salt, but its solutions in them appear to decompose gradually. When exposed to the direct rays of the sun it explodes violently, even when the vessel containing it is surrounded by iced water. In diffused daylight decomposition takes place more slowly, but the liquid becomes gradually warm, and after a time boils

violently, and leaves only a little acid liquid smelling of ethyl acetate. In its general properties it resembles hypochlorous oxide very closely, and acts on ammonia and many organic substances as a strong chlorinating and oxidizing agent. It immediately decomposes hydrobromic and hydriodic acids, liberating the halogens.

In the study of the "Nitro-Derivatives of Ethylene" A. Villiers (*Bull. Soc. Chim.* 48, 422–424) obtained the compound $C_2K_2(NO_2)_4$ by the reduction of the potassium-derivative of tetranitroethylene bromide (Abstr., 1884, 33). This body undergoes decomposition after several days, forming a purplish-brown amorphous mass; potassium-hydrogen carbonate is also formed, and small quantities of an unstable substance soluble in water with an intense red color. By treating the compound $C_2K_2(NO_2)_4$ with chlorine, bromine or iodine in the presence of potash, tetranitroethylene chloride, bromide or iodide is formed. The aqueous solution of the potassium compound of tetranitroethylene bromide is slowly dissociated, an oily, colorless liquid being formed, which appears to be tetranitroethylene bromide. The *silver* compound $C_2(NO_2)_4Br_2Ag_2O$ crystallizes in brilliant yellow needles; it detonates at about 100°, and at 40° it is exploded on the slightest friction, although it cannot be exploded by friction at the ordinary temperature. It is blackened by the action of light. The *potassium* compound of tetranitroethylene chloride $C_2(NO_2)_4Cl_22KHO$ forms pale yellow crystals; it detonates at 147°. The corresponding iodine compound crystallizes in yellow plates, which alter rapidly and become black; it explodes at a higher temperature than the chlorine and bromine compounds, but causes a much more violent explosion. In the preparation of tetranitroethylene bromide (Abstr. 1882, 815) the flask is cooled by immersing it in cold water directly the action tends to become at all violent, and the operation is then conducted as usual; the formation of nitrous gas is almost entirely avoided, and much smaller quantities of other ethylene compounds are formed. The further reduction of tetranitroethylene bromide results in its complete decomposition into ammonia, and hydrogen cyanide and bromide. A small quantity of an alkaline compound was, however, obtained by treatment with ammonium sulphide; it contained potassium and sulphur, and formed a beautiful orange platinochloride. (Abstr. *Jour. Chem. Soc.* 1044, Oct., 1885.)

The following "Nitro-Derivatives of Furfurane" were studied by P. Priebs (*Ber.* 18, 1362; 1885). *Nitroethenyl furfurane,*

$C_4H_3O.C_2H_2.NO_2$, is readily obtained by acting on furfuraldehyde in an alkaline solution with nitromethane. By treating this compound with nitric acid, *nitroethenylnitro-furfurane*, $NO_2.C_4H_2O.C_2H_2.NO_2$, is formed. When this is oxidized with chromic mixture it yields *nitro-pyromucic acid*, $NO_2.C_4H_2O.COOH$. This forms an insoluble silver salt which explodes on heating.

In referring to the statement that "Franklin,* in his Letters on Electricity (June 29, 1751), was the first to suggest the employment of frictional electricity for ignition of gunpowder," it may be interesting to note the following item from the *Maryland Gazette*, Annapolis, Md., June 14, 1749: "On Friday last (June 9), the gentleman who has exhibited the electrical experiments in town removed his machine off to the south side of our creek [Spa Creek ?], and having set some spirits of wine in a small vessel on a table on the north side, he caused a spark of electrical fire to dart across in an instant through 200 yards of water, which set the spirits in a blaze the first attempt and several times afterwards, and discharged a battery ef eleven guns, to the surprise and great satisfaction of the spectators." The name of the exhibitor is not given, although an advertisement of his exhibition, together with a detailed list of his experiments, is repeated in several of the previous numbers.

* Proc. Nav. Inst., **11**, 773; 1885.

PROFESSIONAL NOTES.

SUBMARINE BOATS.

By Mr. T. Nordenfelt.

[From *United Service Gazette.*]

The principal *raison d'être* of a submarine boat is the suddenness of its attack, and if the attack by torpedoes fired from a submarine boat is more effective than that fired from a surface boat, while the crew is less exposed in the submarine boat, it should find its place amongst the armaments of nations.

[Mr. Nordenfelt then enumerates the various submarine boats that have been invented since Bushnell's attempt to blow up the Eagle in 1776.]

The idea seems throughout to have been admitted that submarine boats, if successful, would become most valuable and comparatively inexpensive weapons for port defense; but none of the boats so far had given satisfaction, and I now beg to give my views as to the reason of their failure.

1. They were always built too small and too weak. The longest of previous submarine boats was 45 feet, or about half as long as my boats. Their small dimensions and weak plates made them useless in bad weather and dangerous for submersion, especially if touching the bottom or if coming in contact with any vessel.

2. They have never been made for firing a fish torpedo, consequently they have had to endeavor to fix a mine to the bottom of a vessel, which I consider impracticable, considering the risk of contact with the vessel, which, especially if pitching or moving, might easily destroy the boat. This also necessitates a complication of clock-work or electrical connections to enable the boat to get away, to avoid the fatal risk of being destroyed by the attacked vessel, as was the case with the boat which sank the Housatonic.

3. In all the early boats the mines were charged with only black powder, the effect of which was less destructive than that of the gun-cotton or dynamite in the fish torpedoes; and the effect of the explosion against a wooden ship was nothing like as serious as against the thin bottom plates of an ironclad.

4. All the boats hitherto in use have been propelled by hand power. This gave too much hard work to the crew, who could not take the boat any distance on the surface previous to the actual attack, and made it quite impossible to face any rough weather. In my boats, the use of steam diminishes the number of men, and they have so little to do when below the surface, that the temperature, which is anyhow lower than in modern stokeholes, is no detriment; the stokers, for instance, in my boats have nothing to do when the boats are submerged. My boats can go 150 miles and upwards, previous to the attack, without re-coaling.

5. All previous boats had most unreliable means of descending and ascending. The descent by steering downwards, in the American boats, twenty years ago, was quite as dangerous as the attempts before and after that time to lower and raise the boats, and to keep them steady at any desired depth, by means of increasing and decreasing the weight of the boats by more or less water-ballast, or by altering their displacement. None of those boats used the

principle which I have applied to pull the boat down by mechanical means, while relying upon its always-retained buoyancy for rising; so that if the mechanical apparatus fail, the boat rises at once to the surface. I consider it absolutely essential to keep the boat horizontal when moving, as any inclination downwards, with the impetus of a heavy boat, would almost to a certainty carry the boat below its safe depth before it could be effectually counteracted by shifting weights. The position, then, as regards torpedo warfare, seemed to me to be as follows: The submarine mines, placed at the bottom or floating anchored, had been adopted generally; but they were acknowledged not to fully satisfy the requirements for port defense, because they were immovable, and were exposed to be picked up by the enemy. The towed torpedoes of the "Harvey" class had not given satisfaction, and the spar torpedoes could only be used under very exceptional circumstances. The "Whitehead" and "Schwarzkopf" fish torpedoes were then the only ones that gave any hope of usefulness by future development. The fish torpedo is practically a projectile, and the torpedo boat may be called the gun which fires it; and the great expense in time of peace, added to the certainty to lose a number of these boats in war, made this means of discharging torpedoes exceedingly costly and unreliable. It seemed to me, therefore, of great importance to construct a means of carrying, with greater safety, the fish torpedoes up to such a short distance from the vessel to be attacked that the torpedo could not fail to hit. The surface torpedo boats at that date were met by machine guns, which made their attack in daytime almost impossible; and the improvements in the direction of greater speed and thicker protection of their vital parts have been met by greater power and longer range of the quick-firing machine guns, while their larger dimensions offer a target more easily hit. Thus, to-day, the surface torpedo boats really do not offer much greater certainty to reach striking distance than they did five years ago.

It seemed to me that a much greater chance would be given for carrying the Whitehead torpedo within striking distance if, instead of trying to rush the distance by many boats, all the time exposed to the destructive fire from machine guns, I could carry the torpedo secretly up to this distance without the probability of being seen at all, and without any probability of being struck by the enemy's shot, even if seen. This led me to take up the question of submarine boats; and I thought it best to build at once such a submarine boat as could not be suspected of being only an experimental boat, but one really useful in war.

The first boat I built at Stockholm, and which I had the honor to run at the experiments in Sweden last September, in the presence of delegates from most of the leading Governments. The following are its principal dimensions and details: Length, 64 feet; beam, 9 feet, but over sponsons 12 feet; draft, 11 feet; displacement, 60 tons; speed, on measured mile, 9 knots; distance travelled without re-coaling, 150 miles; depth to which it can safely descend, about 50 feet. Engines, surface-condensing compound type, with two cylinders and cranks at 90°, and, at pressure of 100 pounds to square inch, will indicate 100 horse-power. Boiler of ordinary marine return-tubes type, having one furnace and about 200 square feet of heating surface. Two hot-water cisterns, rhomboidal in body, with spherical ends. The boilers and cisterns contain about eight tons of water. Both boilers and cisterns are made for a working pressure of 150 pounds to the square inch. One fish torpedo, 14 feet, is carried outside on the bow, and discharged mechanically. The sinking apparatus consists of two vertical propellers driven by a 6 horse-power double-cylinder engine. These propellers are placed in sponsons on each side of the boat. One cold-water tank in centre of boat, holding about four tons of water for regulating buoyancy. This tank is used as coal bunker when doing long surface runs. Crew, three men. For longer distances, out of sight of the enemy, the boat runs on the surface, with the cupola and about three feet of its turtle back out of water, but by forced draft, blowing out its smoke under the surface.

When the boat arrives within such distance of the enemy that it might be discovered, it descends into the water so far that the cupola alone appears above water; this is done by taking in water into the cold-water tanks sufficient to reduce the floatability to what my horizontal screws are capable of overpowering; she runs thus "awash" until she arrives so near that even the small cupola might be discovered; then she descends altogether below the surface and advances up to striking distance entirely submerged, unless she requires to show the cupola above the surface once or twice for a few seconds to adjust her direction. The above-named reduced floatability is never done away with, but the descent from the "awash" position is effected by starting the horizontal screws, thus overcoming mechanically the buoyancy of the boat, which is pulled down to a less or greater depth, depending upon the speed given to the horizontal screws. As the density of water does not alter at varying depths, I can always count upon the exact amount of buoyancy being available for raising the boat to the surface whenever I stop the horizontal screws, or for lifting the boat nearer to the surface when I reduce the speed of the engines driving them. Thus, if any failure of these engines or propellers were to take place the boat would at once rise to the surface. In addition to my controlling the depth by varying the speed of the horizontal propellers, I have applied an apparatus for definitely regulating the depth at which I mean to move; this consists of a valve which controls the steam supply to the small engine; this valve being held open by a weight adjustable on a lever, the piston of the valve is also in direct communication with the sea, in such a manner that when I reach a depth at which the pressure in the sea is more than the pressure of the weight, the valve closes, the engines stop, and the buoyancy raises the boat until the outside pressure diminishes, when the weight again opens the valve. By this means I regulate exactly the depth at which I desire to move. When descending below the surface I carry altogether about eight tons of water, subject to the full pressure of steam, so that in case of more leakage than I can pump out of the boat by my steam pumps, I can at once counteract such leakage and rise to the surface by blowing out water. This must be much more reliable than to detach weights. On the surface I drive the boat by working the boiler in the usual manner, and I keep up the temperature of the water in the cisterns to a degree corresponding to a steam pressure of 150 pounds. When I wish to descend I close the ashpit and firedoor; then I close up the funnel inside boat and start the horizontal propellers. At this moment I thus have, as propelling power under water, the steam which will be given off by the heated water (about eight tons), and this has been found sufficient for a distance run of 14 knots, or more than is required for an attack in war. On that occasion we had still over 20 pounds pressure in the boiler when the boat was opened up. The boat is laterally very stiff, as I carry some six tons of lead in the bilge. Longitudinally the boat is balanced before starting by the arrangements of weights, and this can be adjusted by having more or less water in the two cisterns fore and aft. When descending the boat is perfectly horizontal, and is invariably kept so when moving under water by means of the bow rudders operated by a plumb weight. These bow rudders have been found to act so perfectly that there is actually no appreciable change from the horizontal position. Although the centre of gravity is well under the metacentre, the boat is so sensitive longitudinally that the bow rudders correct instantly any tendency to deviation from the horizontal position. Three men are sufficient crew for the boat, and I have proved that these men do not require any other air for sustenance in comfort than what the air space in the boat itself contains.

The dimensions of this first boat, as well as its speed and proportions, were settled especially for defense of coasts where there is an archipelago, as in Sweden, the west of Scotland, etc., and for the defense of ports with long estuaries—for instance, London, Liverpool, etc.—and I am still convinced that where handiness and small draft of water are important factors these propor-

tions cannot be much improved upon. The lines of my beats are drawn specially suitable for giving least resistance when the boats are submerged, consequently they are not so good when part of the boat is above water. The surface speed of my small boat being 9 knots, she is capable of even greater speed when submerged. Thus she can always, whether on the surface or below, do 4 to 5 knots against a 4-mile current. The question of what speed below water is most desirable must be found out by experience, and must depend upon the room and depth of water available, and upon how far greater speed, when submerged, may tend to detract from the secrecy of attack, and upon other questions which can only be determined by lengthened practice by intelligent officers, when fully trained to its use.

The three main points in my system of submarine boat to which I particularly wish to draw attention are: 1st. That by using water as the means of storing up energy, I am in possession of a reservoir which can never get out of order and which can be replaced at any hour in any part of the world, and without any extraneous assistance from shore or other ships. Whereas, if electricity were used, delicate and special apparatus would have to be employed as reservoirs of energy, such as accumulators or batteries, which if they should require repair or replacement would render the boat completely *hors de combat*, unless she were within reach of some electrical depot. Also, the durability of the cistern containing the water is immensely greater than of electrical apparatus, which—should a run of any distance be required—would still have to be provided with engines for the replenishing of their power. These objections also lie against the use of caustic soda or compressed air. Besides, after carefully investigating what could be done in other ways, I was fully convinced that I could by no other method store so much energy as by using heated water, especially as I have made it a point to design engines for my boats in such a manner that as long as I can have high pressure in my boiler I can use expansion; yet as the pressure falls in the boiler by reason of the steam being used when under water, I can regulate my engines so that they will work well down to and even below the atmospheric pressure. The reason of all others which at once decided me to adopt the hot-water system was the enormous factor of safety obtained by my being able to blow out by steam pressure, without the use of machinery, large weights of water, which would lighten the boat and counteract any leak likely to occur. Finally, I preferred to use the hot-water system because, the motive power being steam, ordinary marine engineers are at once familiar with it, and would have more confidence in the boat than if any new, delicate, or comparatively untried system were adopted.

2d. The submerging the boat by mechanical means. I feel confident that previous attempts have proved unsuccessful mainly because either they depended upon varying the displacement of the boat by taking in water to submerge her, and to regulate the depth at which they desired to operate, or they descended by steering downwards. My objection to the first-named method of descending by taking in water, and thus increasing the specific gravity of the boat, is that practically there is no difference in the specific gravity of water on the surface and at 50 feet depth; thus, when the boat has lost its buoyancy at the surface, it has also no buoyancy at any given depth, and the risk is thus very great of suddenly descending beyond a safe depth. Further, by this method they relied upon some mechanical means for ascending by ejecting water. In case such mechanical means failed, the boat would be lost. As regards the method of descending by steering downwards, I need only point out the great risk of allowing an object 100 feet long and of great weight to proceed in the downward direction even at a small angle, as the impetus gained would very easily carry it beyond safe depth so quickly that they might not have time to check it. On the other hand, by my system I rely upon no mechanical means for rising, but keep myself, by means of the speed of the horizontal propellers and the regulators, at any desired depth, with a sufficient force to keep steady when advancing at that depth; and as I never cause the

boat to leave the horizontal position, I am safe against the effect of impetus in a downward direction.

3d. The horizontal position I have found to be a *sine quâ non* for a submarine boat, and I have already above shown the great risk in allowing the boat to descend at an inclination. I have therefore provided rudders, which I prefer to place in the bow of the boat, and which by the action of a plumb weight are always held in the horizontal position, and therefore, should the boat from any cause tend to take a direction other than the horizontal, these rudders will immediately bring the boat back to the horizontal position. During experiments continued for a couple of years, I have found these rudders perfectly reliable, and they have never failed to effect their purpose. In addition to these three main features of my submarine boats, there are a few more points to which I wish to direct attention. There is really no trouble at all about the heat or the sufficiency of sound fresh air in the boats. The heat after the 14 miles' run above named was only 32° C. (90° F.), and after the first run at Landskrona, when the crew had been closed in from the outer air for three hours, the temperature was taken by two of the delegated officers at 31° C. (88° F.), while I am informed that in some monitors the stokehole temperature rises to 49° C. (120° F.), and I suppose it is not much cooler in some of the larger modern ironclads. As to the purity of air, there have been four men enclosed in the boat for six hours without any appreciable diminution in the length of flame of a tallow candle placed on the floor, the level where the air should be most impure.

I have not had the slightest difficulty in finding crews. My first engineer was one from the merchant service, my second one was engineer in the Swedish Navy, and my third one was again a civilian; any number of stokers have always offered their services, and many Swedish naval officers have urged me to let them command the boat. The risk to the crews ought to be very slight, and in war I consider that they would be safer in my boats than in many other positions. In case of accident the boat can always come to the surface, and the men can escape with life-belts. My compasses work in the same manner as in all other iron ships; that is, they do not work as satisfactorily as when raised far above the iron; but, as they work exactly the same whether the boat is on the surface or submerged, I can always take the bearing before descending and then be safely guided by the compass below. Lieutenant Hovgaard suggests that some electrical power should be carried in accumulators in addition to the steam power; this can, of course, be done if found useful; but I would prefer to avoid complication by carrying the weight of such accumulators in additional heated water. The main safety of the boat, of course, lies in the utter improbability of the enemy knowing that the boat is near, or that any attack is intended; next, it lies in the very short period of a few seconds in which the cupola appears above water, and which would generally not be long enough to enable the enemy's guns to ascertain the range. If the cupola is hit the boat is not disabled, as there is a cover which can at once be slung across the opening and make it water-tight, so that the boat can again descend out of sight, and go away to put on a spare cupola.

My boats are armed with one or two Whitehead torpedoes in tubes, and as soon as my controlled electrical torpedo is ready I propose to tow one of these as well. This torpedo will offer the advantage that steel-wire nets would be no protection against it, as the nets would be torn asunder or brought close to the ship's side by the impetus of the torpedo, weighing four tons, striking with a speed of fifteen miles an hour, so that its charge of 300 pounds of dynamite must explode as near to the ship as is required to make this heavy charge thoroughly effective.

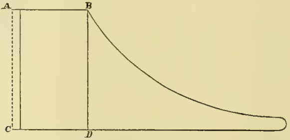
C. B.

CONDENSATION IN STEAM CYLINDERS.

[From *London Engineer*.]

No subject connected with the steam engine has received more attention than the condensation which takes place in the cylinder. Its theory is complete, and yet all the information possessed on the subject is strictly indirect, and no one knows at this moment precisely what takes place in a cylinder, nor will they know until experiments of an entirely novel character are undertaken and carried out by some competent authority. This ignorance manifests itself in various ways. The widest diversity of opinion, for example, exists concerning the utility of the steam jacket, about which there ought to be no uncertainty whatever if the accepted theory of condensation is really true; and extraordinary statements are made, by men of no mean authority, which it is almost impossible to prove or disprove. A very large quantity of water will find its way through an engine without making its presence felt by being stopped against the cylinder heads. If any engine ought to be free from condensation in the high-pressure cylinder, the triple-expansion engine would be that one. But experience has demonstrated that the high-pressure cylinder is always drowned with water, with the best boilers, and this with the jackets in full work. In a triple-expansion engine tested for this purpose last summer, it was found that whether the jackets were full of hot water or carefully blown down, there was no perceptible difference; and it was impossible to get a diagram free from the influence of water in the cylinder, and the indicator-cock always blew wet steam. The low-pressure cylinder, on the contrary, never betrayed the presence of water, and it was unjacketed. It is proposed here to consider the phenomena as they seem to exist, and to direct attention to the line which experiments should take.

The theory that steam condenses in a cylinder is based on very simple facts. 1. The presence of water is recognized by sight when an indicator-cock is opened, and by the continued dropping of water from high-pressure glands. 2. It is proved by direct experiment in the following way: In the accompanying diagram, the space *ABCD* represents the full-pressure part of the stroke.



The dotted line shows the clearance space. Suppose a cylinder 2000 square inches of piston area. It will be nearly 50½ inches diameter. Let the steam be cut off sharp when the piston has made 9½ inches stroke. Allowing ½ inch for clearance space, the cylinder and clearance will contain

$$10 \times 2000 = 20{,}000 \text{ cu. ins.} = 11.574 \text{ cu. ft.}$$

If the pressure is 100 lbs. absolute, 1 cu. foot will weigh .2307 lb. and 11.574 × .2307 = 2.67 lbs. = weight of steam per stroke accounted for by the indicator, and this result, multiplied by number of strokes per hour and divided by the indicated horse-power, will give the weight of steam used per hour per indicated horse-power. If now the quantity of water pumped into the boiler per hour is weighed, and this weight divided by the indicated horse-power, the

result will give, making an allowance of from 5 per cent. to 10 per cent. for insensible priming, the weight of steam supplied per hour per indicated horse-power by the boiler. In all cases, the latter figure exceeds the former; thus, the indicator showing, say, 13 lbs. per hour per horse-power, the weight of water pumped into the boiler may be 20 lbs. to 25 lbs. It is seen that the indicator accounts for 2.67 lbs. per stroke. The actual quantity of steam supplied by boiler may be 3.67 lbs.* What becomes of the difference? The answer is simply that it is mainly condensed by coming in contact with the cold cylinder, a small proportion being liquefied by the performance of work. This quantity is, however, so insignificant that it may be neglected.

It is very necessary that the bearings of this assumption should be fully comprehended. The usual mistake is to mix up all the cylinder condensing surfaces together—to regard, in a word, the whole cylinder as playing the part of a condenser. A little reflection will suffice to show that this is quite wrong. The boiler can only supply steam while the admission valve is open. The moment the cut-off closes, the cylinder is isolated from the boiler, and the steam does its work during expansion just as though the boiler never existed. During this the expansion part of the stroke, condensation may or may not take place. Whether it does or not, however, will not affect the weight of steam supplied to the engine, though it will affect the power developed, and therefore the weight of water used per horse-power. To prevent confusion, disregard the horse-power and deal only with what takes place per stroke. If no condensation took place, 2.67 lbs. would have sufficed under the conditions laid down. In point of fact, 3.67 lbs. are needed. Consequently, one pound of steam must be condensed at every stroke by surfaces of one head, one piston face and a belt 10 inches deep of the cylinder—or say, 5590 square inches, or in round numbers 39 square feet. The temperature of steam of 100 lbs. pressure is 328°. Thus one pound of steam can give up 883 units, or to each square foot about 22.6 units only. Thus it is clear that a small weight of iron will suffice to do all the condensing required, if only it is cold enough to begin. If its temperature has fallen to, say, 200°, then, the specific heat of iron being about one-ninth that of water, each nine pounds of iron would require 128 units to restore it to 328°, the temperature of the incoming steam. As there are only 883 units available, $\frac{883}{128} \times 9 = 62$ lbs. = weight of iron to be heated at each stroke. From which it appears that the temperature of the metal need not be affected to a greater depth than about $\frac{1}{25}$th of an inch to account for the condensation which takes place.

The figures and facts given are those commonly used to explain what goes on inside a cylinder. It is hard to dispute the accuracy of such reasoning, as regards single-cylinder engines; but the moment this line of argument is applied to compound or triple-expansion engines, difficulties arise. In the first place, the range of temperature will not be in the high-pressure cylinder more than about 47 degrees, instead of 128 degrees, and the steam in the jacket being at least as hot as that going into the cylinder, the cylinder walls should be maintained at so high a temperature that condensation in the cylinder is impossible. Under these circumstances it is difficult to explain why condensation takes place, and it is usually stated that none or next to none does occur; but facts entirely refute this, as much as 30 and 40 per cent. of the steam being reduced to water—as much being condensed as though the engine had but one cylinder; and so doubtful is the advantage of jacketing, that engineers neither know what cylinder to jacket nor whether it is worth while to jacket all or none.

But there are further puzzles to be solved. How is it, for example, that the

* It must be understood that 3.67 does not represent what will of necessity occur; the difference between the steam accounted for by the indicator, and actually supplied, is a very uncertain quantity, varying not only with different engines, but with the same engines under different conditions of load, speed and expansion.

low-pressure unjacketed cylinder, open at each stroke to the frigerific influence of the condenser, does not condense steam, but, on the contrary, re-evaporates the water carried to it from the intermediate cylinder? It is well known that while some 30 per cent. of all the steam made by the boiler may be condensed in the high-pressure cylinder before the cut-off valve closes, nearly the whole of this will be re-evaporated in the intermediate, and especially in the low-pressure cylinder. It may be taken as proved that a cylinder cannot evaporate more steam than it condenses, because all the heat available for re-evaporation during one stroke must have been imparted to the metal by steam during the preceding stroke. Yet the low-pressure cylinder is found actually acting like a boiler, taking in wet steam continually, and sending it away dry, or at least dryer than it was when it got it, the expansion curve often rising above the curve normal to the pressure and rate of expansion.

Further direct experiment is wanted to settle such problems as those cited. The thing to be ascertained is the actual rise and fall of temperature in the surface of the metal of a cylinder; the solution of this problem is attended with difficulties, but they are not insuperable.

It may be asked how it happens that the triple-expansion engine is so economical if condensation takes place in it to such a large extent. The answer to this question has already been given. Almost all the water resulting from condensation in the high-pressure cylinder is re-evaporated in the others, and the resulting steam being worked expansively, great economy ensues.

J. K. B.

BAIRD'S ANNUNCIATOR.

CHIEF ENGINEER'S OFFICE, U. S. NAVY YARD,
WASHINGTON, *December* 19, 1885.

Sir:—In compliance with instructions of the Bureau of Steam Engineering dated the 15th, and your order dated the 16th instant, the board appointed to examine the device described as "Baird's Annunciator" have examined the apparatus, observed its operation, and beg leave to report as follows:

The object of the device is to indicate upon deck, to the easy inspection of the officer in charge of the deck or his assistants, the direction of the movement of the engines, whether ahead or aback.

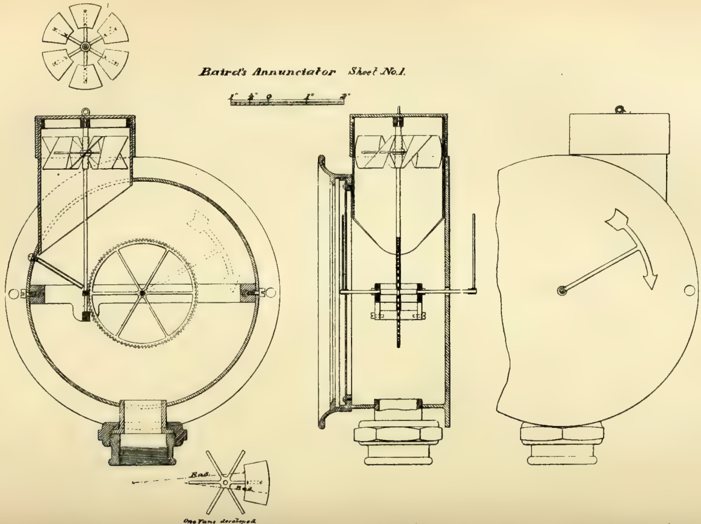
While the engines are working ahead an index revolves in the direction in which an arrow, on its free extremity, points; upon reversing the engines the motion of the index is reversed.

The mechanism immediately employed in producing these movements is enclosed in a case, of which the dial over which the index revolves is the face. The index is mounted upon a shaft or spindle, which carries a toothed wheel.

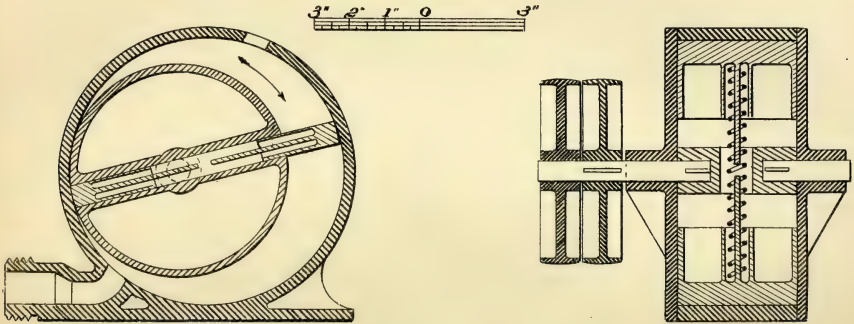
The wheel and spindle are turned by the revolutions of a second spindle placed at right angles with the first, carrying a worm or endless screw, the threads of which mesh with the teeth of the wheel. The second spindle carries also a series of fans, arranged like the blades of a screw propeller, or like the vanes of the common anemometer.

By means of an air-current, which flows in one direction when the ship's engines are going ahead, and in the opposite direction when they are backing, the fans and their spindle are rapidly revolved, and the proper motion transmitted through the spiral gearing to the index. The movement of the index is moderate in speed, but the speed is variable with the speed of the engine, and incidentally affords a means of estimating, by the eye, the speed as well as the direction of the movement of the engines and the ship.

The air-current is derived from a small rotary blower placed near the engine


Baird's Annunciator Sheet No. 1.
1" ½" 0 1" 2"
Rad.
Rad.
One Vane developed.
ISAAC FRIEDENWALD LITH BALTO

Baird's Annunciator. Sheet No. 2.



ISAAC FRIEDENWALD LITH BALTO

shaft, and turned by it through the operation of belts. When turned in one direction, the blower draws the air from the vanes of the annunciator through a pipe, in one enlarged extremity of which, forming a mouth, the vanes revolve. When turned in the opposite direction, the air is driven through the connecting pipe to the vanes, and the direction of the movement of the latter upon the instant reversed.

It is a very great advantage to the person manœuvring the ship to know, without the delay attending inquiry, or observation of the movement of the ship herself, exactly what the latter is to be. Should mistake be made, it will be apparent before it is too late to correct it.

The apparatus is simple and elegant, the power consumed by it is inconsiderable, and it is not at all likely to get out of order.

Its first cost needs never to be great, and the cost of maintenance is trifling. Drawings of it are hereto appended.

The board recommends it for purchase and use for purposes under cognizance of the Bureau of Steam Engineering.

We are, sir, very respectfully, your obedient servants,

CHARLES H. BAKER,
Chief Engineer, U. S. N.

R. D. TAYLOR,
P. Asst. Engineer, U. S. N.

R. R. LEITCH,
P. Asst. Engineer, U. S. N.

COMMODORE W. W. QUEEN, U. S. N.,
Commandant.

U. S. NAVY YARD, WASHINGTON, COMMANDANT'S OFFICE,
December 24, 1885.

Respectfully referred to the Bureau of Steam Engineering.

W. W. QUEEN,
Commodore, Commandant.

CLOSED FIRE-ROOMS.

From an abstract of a paper recently read before the Institute of Naval Architects by Mr. Richard Sennett, the following data on forced combustion have been obtained. The object of the paper was to supplement the information obtained from the trials of the Satellite and Conqueror by details of the trials of H. M. S. Rodney, Howe, Mersey and Scout.

The proportions of the boilers and engines of the Rodney are such as to give with natural draught about 8000 indicated horse-power. With forced draught on a four hours' trial, the mean indicated horse-power developed was 11,158, with an air-pressure of 1.4 inches of water. On the forced-draught trial of the Howe, a sister ship of the Rodney, the mean indicated horse-power developed was 11,728. The proportions of the boilers and engines of the Mersey would under natural draught give about 4000 indicated horse-power, while under forced draught the trials gave a mean of 6628 indicated horse-power, with an air-pressure in the fire-room equivalent to 2 inches of water.

Mr. Sennett states that, from the experience the Admiralty have now gained respecting the steam-generating powers of boilers in closed fire-rooms kept under moderate pressure, and the well-known economical employment of steam in triple-expansion engines, they are satisfied that on the full-power trials of these vessels at least 20 indicated horse-power per square foot of grate, and between 23 and 24 indicated horse-power per ton of boiler, will be realized, and this condition has been readily accepted by the engine contractors. The

maximum limit of the air-pressure allowed on the Admiralty trials was equal to 2 inches of water. This pressure, with further experience, will probably be made higher, with a corresponding increase in the steaming powers of the boilers. The closed fire-room system tends to promote economy of fuel, in consequence of the better supply of air and the higher temperature at which the fires are worked.

J. K. B.

TABLE I.—ABSTRACT OF STEAM TRIALS.

	Open Fire-Room.			Forced Draught.					
	Inflexible.	Colossus.	Phaeton.	Mersey.	Scout.	Rodney.		Howe.	Caroline.
Date of trial	Nov. 14, 1878.	Jan. 10, 1884.	Feb. 12, 1884.	Sep. 24, 1885.	Sep. 23, 1885.	June 13, 1885.	June 16, 1885.	Jan. 14, 1886.	Mar. 4, 1885.
Duration of trial in hours	6	5	5	3	4	4	3	4	6
Number boilers used	12	10	8	6	4	12	9	12	2
Mean pressure in boilers, pounds	61.06	61.52	85.35	107.8	113.09	93 06	92.74	89.21	84.52
Mean air-pressure in fire-room in inches of water.	....	....	....	2.02	1.52	1.4	1.89	2.05	1.5
Mean pressure in cylinders { High pressure	29.55	40.66	43.56	56.53	61.42	59.92	49.73	59.51	43.9
Mean pressure in cylinders { Low pressure	9.83	12.09	11.43	22.82	24.31	12.8	12.1	13.43	12.79
Mean revolutions per min	73.26	89.96	100.26	122.34	152.33	103.42	100 13	106.63	77 8
Mean speed of piston, feet per min.	586	585	802	795	762	776	751	800	389
Indicated horse-power	8483	7492	5588	6628	3370	11158	9544	11725	983
Area fire-grate used, square feet	829	645	546	399	207	756	567	756	545
I. H. P. per square foot of grate	10.21	11.62	10.23	16.61	16.28	14.75	16.83	15.51	18.02
Heating surface per I. H. P. in sq. feet { Tubes	2.20	1.97	2.23	1.56	1.63	1.54	1.35	1.46	1.24
Heating surface per I. H. P. in sq. feet { Total	2.63	2.33	2.61	1.77	1.83	1.82	1.6	1.73	1.43
Coal used per I. H. P. per hour, pounds	2.06	2.55	2.39	2.48	2.6	2.2	....	2.16	2.54
Coal used per hour in tons	7.80	8.53	5.96	7.33	3.92	11	....	11.30	11.11
Remarks	Blast used last half hour only.	Blast used through-out the trial.	Natural draught only.						

NOTE.—The I. H. P. recorded is that developed by the main engines only, and does not include the I. H. P. expended in working the feed and circulating pumps, and other auxiliary machinery.

TABLE II.

1.		2.	3.	4.	5.	6.	7.	8.
	Ship.	Date.	Load on safety-valve.	I. H. P.	Weight of boilers.	Area of fire-grate.	I. H. P. Per sq. feet of fire-grate.	I. H. P. Per ton of boiler.
			Pounds.		Tons.			
Open fire-room.	Inflexible	1878	60	8483	756	829	10.21	11.22
	Colossus	1883	64	7492	594	645	11.62	12.61
	Phaeton	1884	90	5588	462	546	10.23	12.1
Forced draught.	Howe	1885	90	11,725	632	756	15.54	18.5
	Rodney	1885	90	9544	474	567	16.83	20.1
	Mersey	1885	110	6628	306	399	16.61	21.7
	Scout	1886	120	3370	174	207	16.28	19.3
	Trafalgar (estimated)	....	135	12,000	514	609	20.00	23.3

NOTE.—The weight of boiler given includes weight of water, funnel, uptakes, fittings, spare gear, etc.

DETERMINATION OF CURRENTS BY A SERIES OF FOUR ALTITUDES.

From the French of J. Réveille, Professor of Hydrography.

I.

If at sea three simultaneous star altitudes are observed, the three corresponding lines should cut, which point is the true position of the ship. In general this will not be, and the three lines will form a triangle, due to a personal error, measured by the radius of the circle inscribed in the error triangle, or sometimes the radius of one of the inscribed circles.

In what follows we shall suppose the personal error eliminated.

II.

The ship's position can be determined by a series of altitudes taken at different moments, called interval altitudes. In fact, without much error, we can suppose the ship carries with her, parallel to themselves, her lines of altitude, which are geometrical lines of her position, converging to the real point. Suppose four interval altitudes have been taken, referred to the fourth horizon and corrected for personal error; they should pass through one point. Generally this does not happen, for if the observations are repeated in the same whereabouts, systematic errors quickly are seen, which are attributed to current action.

Mr. Fasci, Professor of Hydrography, remarks that the direction of the cur-

rent is obtained by tracing the line cut by the altitude lines into segments proportional to the time intervals separating the observations.

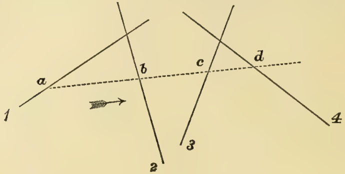


FIG. 1.

Let 1, 2, 3, 4 be four altitude lines referred to the fourth horizon; let a, b, c, d be the direction of the current, and let d be the ship's position.

The line 3 should have cut 4 at d; hence the ship has moved by current from c to d, similarly from b to c, and from a to b. Assuming the strength of the current constant, the distances passed over are proportional to the time intervals; hence the line *abcd* can be traced, cut by 1, 2, 3, 4, as given.

Mr. Fasci gives a practical solution of this problem. The solution to be given may not be more practical nor simpler, but its examination leads to geometrical considerations that give renewed interest to the question.

III.

1. Let 1, 2, 3, 4 be the four altitude lines; *abcd* the line sought; the segments *ab*, *bc*, *cd* are proportional to the numbers m, n, p, and we have

$$\frac{ab}{m}=\frac{bc}{n}=\frac{cd}{p}.$$

All lines cut into segments by 1, 2, 3 proportional to m and n touch a certain curve that is their envelope; the same for all lines cut by 2, 3, 4 into segments proportional to n and p. The line sought will be a common tangent to these two curves.

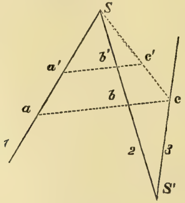


FIG. 2.

Draw separately the lines 1, 2, 3 (Fig. 2). Draw any line $a'b'$ that cuts 1 and 2 at $a'b'$ and take on this line a point c', so that $\frac{a'b'}{m} = \frac{b'c'}{n}$. Join this point to S, the intersection of 1 and 2; Sc' will cut 3 at c. Draw through this point a line parallel to $a'b'$; this will be cut by 1, 2, 3 in the relation of $\frac{m}{n}$; it will be a tangent to the curve envelope drawn parallel to the direction $a'b'$.

As the line Sc' meets 3 only at one point, but one tangent ab parallel to $a'b'$ can be drawn. Hence:

The curve envelope sought is such that but one tangent can be drawn to it parallel to a given direction.

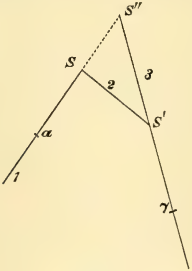


FIG. 3.

2. It is easy to see that the lines 1, 2, 3 are tangents to the curve envelope. Prolong 1 (Fig. 3) until it meets 3 at S'', and take a point a on 1 such that $\frac{aS}{m} = \frac{SS''}{n}$. It is evident that if we wish to draw through the point a line divided by 1, 2, 3 in the relation of $\frac{m}{n}$, 1 fulfils the conditions. This line, therefore, is tangent to the curve envelope, and a is the point of contact. In the same manner it can be shown that 2 and 3 are also tangents, of which the points of contact divide SS' and $S'S''$ (noting signs) in the relation of $\frac{m}{n}$.

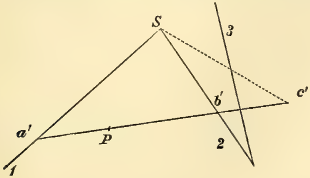


FIG. 4.

3. Let a line $a'b'$ pass in any direction through any point P (Fig. 4). Upon this line select a point c' so that $\frac{a'b'}{m} = \frac{b'c'}{n}$.

To each line $Pa'b'$ a point c' corresponds; all these points form a curve whose intersections with 2 give the points c that must be joined with P to have the lines passing through P, and divided by 1, 2, 3 according to the required conditions. Where is c? Join Sc'; to each line $Pa'b'$ but one point c' corresponds, consequently but one line Sc'. Inversely to each line Sc' but one line Pc' corresponds, as but one line can be drawn through a point cutting the three converging lines (1, 2, Sc') and fulfilling the given conditions. Thus, it follows that the lines Sc' and Pc' correspond homographically, and the locus of the points c' is a conic passing through S and P. This conic cuts 3 in two places; there are, therefore, two points c, consequently two lines Pc passing through P, divided by 1, 2, 3 in the relation $\frac{m}{n}$. These two lines are two tangents of the curve envelope; and as two can be made to pass through any point, it follows that the curve envelope is of the second class, of the second degree, and is a conic section. We have seen already that but one tangent can be drawn parallel to a given direction; therefore, this conic section is a parabola. The envelope sought is a parabola tangent to the three lines 1, 2, 3 at a, β, γ (Fig. 5).

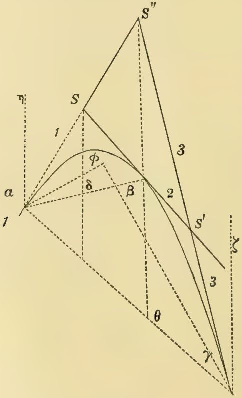


FIG. 5.

4. As the focus of this parabola will be needed in what follows, we shall determine it.

If δ, the middle of the cord of contact $a\beta$, be joined to S, it will give $S\delta$, the

direction of the parabola's axis. The tangent of a parabola bisects the angle formed by the direction of the axis and the radius vector.

We shall have, then, the radius vector $a\phi$ of the point a by forming with Sa the angle $Sa\phi$, equal to ηaS; also the radius vector of γ by drawing $\gamma\zeta$ parallel to the axis and by drawing $\gamma\phi$, making with $S''\gamma$ the angle $S''\gamma\phi$ equal to $S''\gamma\zeta$. Their intersection is the focus of the parabola.

5. Similar demonstration will show that the envelope of the lines divided by 2, 3, 4 into parts proportional to n and p is a parabola tangent to 2, 3, 4, and its focus ϕ' can be determined. Hence, this admitted, it will be sufficient to draw a tangent common to these two parabolas.

Two conics have, in general, four tangents in common. For the parabolas under consideration three of these tangents are known. These are the line at infinity, and the lines 2 and 3; but one remains to be found, and the problem has but one solution.

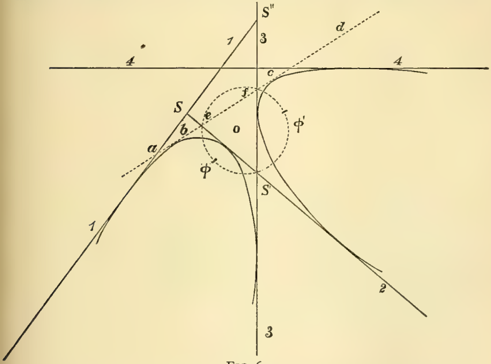


FIG. 6.

Suppose this fourth tangent ef drawn (Fig. 6). The triangle efS' is circumscribed to each of the two parabolas, and the circle circumscribed about this triangle will pass through the foci ϕ and ϕ' of the two parabolas, according to a property to be shown later. Hence this circle o passes through three known points—S', ϕ and ϕ'. We take, then, the intersections ef of this circle with the lines 2 and 3; the line ef will be the common tangent sought, or, as seen above, the line that divided under the required conditions by 1, 2, 3, 4 indicates the direction of the current.

The speed of current can be found by dividing any part of $abcd$ by the corresponding time interval.

The following is the property of the parabola referred to: The circumscribed circle of a triangle, itself circumscribed to a parabola, passes through the focus of the parabola.

The following demonstration we think to be new; it is based upon the consideration of imaginaries in geometry: Poucelet has shown that if a polygon exists at the same time inscribed in a conic C, and circumscribed to a conic C', an infinite number exist. This accepted, let us consider a parabola, and a circle passing through its focus ϕ; let us call I and J the circular points at infinity; these are two imaginary conjugate points. The triangle ϕIJ is inscribed at the circumference, for any circumference of the plane passes through the circular points, and, besides, it passes through the point ϕ. This triangle is circumscribed to the parabola, for the side IJ, which is the line at infinity, is tangent to any parabola of the plane; further, it is known that ϕI and ϕJ are the tangents drawn from the focus of the parabola. The triangle ϕIJ, therefore, is at the same time inscribed in the circle and circumscribed to the parabola. Then, according to Poucelet's theorem, if a circle is made to pass through the focus of a parabola and the two angles of the circumscribed triangle, it will pass through the third angle. E. B. B.

REVIEW.

THE LOSS OF THE OREGON. By R. B. Forbes.

An interesting brochure in which the veteran navigator has collated the most trustworthy accounts of the disaster to the Oregon that have been published. The author makes some valuable professional suggestions, and emphasizes the necessity for more boat and raft capacity for saving life in such disasters. He states that whenever possible there should be a hawser run from the vessel in distress to the rescuing one, to expedite the transfer of passengers, and he cites many interesting examples.

In this connection he advocates that every ship should carry a small mortar for throwing out a line. He strongly advises that mattresses, pillows, stateroom doors and deck seats, should be fitted as life preservers; that there should be arrangements for shutting off steam from the deck in case the firemen are driven up from below; that the boilers should be emptied to make use of their floating power, amounting to several hundred tons; and that ocean steamers should travel in well-defined lanes.

His suggestions are well sustained by reasoning and examples, of which his great experience is prolific. J. W. D.

BIBLIOGRAPHIC NOTES.

AMERICAN INSTITUTE OF MINING ENGINEERS, TRANSACTIONS PITTSBURGH MEETING, FEBRUARY, 1886.

Theories accounting for the recent failure of steel boiler plates in England. Notes on the constitution of cast iron. Proposed apparatus for determining the heating power of different fuels. A new method of laying submarine tunnels and tubes. Peculiar phenomena in the heating of open-hearth and Bessemer steel. Soft steel for boiler plates. The Clapp-Griffith converter. The mineral resources of the Hudson Bay Territories. Miti's castings from wrought iron or steel. The specific gravity of low-carbon steel. The Heine safety boiler. J. K. B.

ANNALEN DER HYDROGRAPHIE.

PART II. Tidal and current observations on the east coast of Africa. Port Hamilton—Notes by the commander of the Nautilus. Caleta Buena in Chili. Meteorological and hydrographic notes.

PART III. Researches of Prof. E. Loomis on the form and motions of cyclones. Notes by the commanders of several German cruisers. Meteorological and hydrographic notes.

PART IV. The sun as the cause of variations in the earth's magnetism and in the Northern Light. The Marshall Islands. Nautical, hydrographic and meteorological observations. Cruise of the Nautilus on the south coast of Corea. Porto Plaza on St. Iago. Temperature coefficients in testing chronometers. Meteorological and hydrographic notes. J. T. S.

BULLETIN DE LA RÉUNION DES OFFICIERS.

MARCH 13, 1886. Repeating arms.

There is no longer any question as to the efficacy of repeating arms; they have been adopted and are being gradually supplied to the European armies. Austria has in use the Mannlicher, a positive-motion gun, the magazine containing 5 cartridges, fired at the rate of 30 a minute. France is experimenting with the Gras-Kropatchek and the Gras-Lee. Germany is substituting a gun which is said to weigh five pounds less than its predecessor. The paper then describes the Hébler gun. C. B.

FRANKLIN INSTITUTE JOURNAL.

MARCH, 1886. The development of dynamic electricity, by Wm. D. Marks.

APRIL. Tornado study, by Lieutenant J. P. Finley. Construction of a large proxy brake, Prof. R. H. Thurston. Summary of engineering and industrial progress for the year 1885, by Dr. Wm. H. Wahl. Report of committee on Delany's system of multiplex telegraphy.

MAY. The blast furnace, by John M. Hartman. Hydrographic work of the United States Navy, by Lieutenant A. B. Wyckoff, U. S. N. The law of cylinder condensation in steam engines, by L. d'Auria.

JUNE. Experiments made at New York Navy Yard to ascertain the economic effect of using in a non-condensing engine saturated steam alone, and of using it mixed with compressed hot air, by Chief Engineer Isherwood, U. S. N.

These experiments were made by a Board of Naval Engineers, with an apparatus submitted by Mr. E. M. Strange, for the purpose of ascertaining how much economic gain, if any, attended the use in a non-condensing cylinder of a mixture of saturated steam and of air compressed to the pressure of the steam and containing its heat of compression. The opening for the passage of the compressed air was in the steam pipe below the throttle valve. The results of the trial showed neither gain nor loss in economy of fuel due to the use of combined air and steam, comparably with the use of steam alone.

To the question: How could any other result be expected? Mr. Isherwood states in substance that the condensation of steam is greatly lessened by the admixture of air with it, as is shown upon a large scale in the atmosphere, which holds aqueous vapor in a state of gas at temperatures enormously below the liquefaction point of the vapor when not mixed with air. Professor Osborne Reynolds has also proved by direct experiment that by mixing air with the steam before it was used, the condensation at the surface of a cylinder may be greatly diminished, and consequently the efficiency of the engine increased. The use of air, however, in connection with steam will not produce any economic effect, unless the two are intimately mixed; merely delivering them in masses avails nothing. There is, of course, great difficulty in producing any such thorough mixture. Time for such mixing is utterly wanting during the operations of a steam engine.

In the experiment with Mr. Strange's apparatus the steam and the air were delivered into the cylinder in distinct masses, separately and successively. There was no time for natural mixing, and no provision had been made for artificial mixing by means of appropriate mechanism; consequently no saving in fuel was produced; but this want of economic effect was not due to any unsoundness or error in the principle or theory, but solely to the fact that the principle was not applied under the conditions requisite for success. And here will be found the explanation of many similar failures in which the practical results were a most disappointing outcome from unquestionably sound premises.

The Oram system of marine propulsion.

The Oram system of propulsion is designed to procure higher speed in steamships, with an increased carrying capacity, and to avoid some of the risks of accident incident to propulsion by stern screws. It consists of an improved form and construction of hull, in which provision is made for a novel location and operation of screw propellers in cavities or recesses on both sides of the vessel.

The propellers are located about one-fifth of the length of the vessel abaft the bow. The cavities in which they are placed are so shaped as to guide the water to and from the propellers with the least possible friction and resistance.

The propellers are susceptible of rotating independently; they are attached directly to the shafts of the engines, on angles of divergence which cause a downward, outward and rearward discharge of the water, attended with a corresponding reaction propelling the vessel.

The advantages claimed for the system are: a saving in weight and cost of machinery; the long shaft and alley to contain it are avoided and the space made available for storage, a degree of elasticity and flexibility in hull construction becomes admissible, which in stern-screw propellers could not be tolerated.

Experiments on the transmission of power by gearing, by Mr. Wilfred Lewis. J. K. B.

JOURNAL DU MATELOT.

No. 12, 1886. By a decree of the Minister of Marine, diverging torpedoes will no longer be used by French ships, and all torpedoes of that type are to be turned into store upon the arrival of a ship at a naval station.

No. 18. The P. & O. S. S. Carthage recently went through the Suez Canal by night, and from the testimony of six of the oldest pilots who were on board, the passage by night is as easy as by day. The passage was made by means of electric lights on board the ship, one ahead, one on each side, and one astern (the latter being used only in the entrances and in the curves), and of ordinary kerosene oil lights on the banks of the Canal.

The electric-light apparatus, including engine and dynamo, is movable, and is taken on board at the entrance and put ashore at the other end; it belongs to the P. & O. Co., and is reserved for the use of their steamers. C. B.

MECHANICAL ENGINEER.

May 29, 1886. U. S. S. Puritan.

A history and description of the Puritan, with full-page illustrations of the engines.

Relative strength of hollow and solid-wrought shafts. Instructions for treatment of mild steel ship-plates. Heating feed-water at sea.

MITTHEILUNGEN A. D. GEBIETE D. SEEWESENS.

Vol. XIV., No. 1. Retrospect of maritime law and legislation, 1884 and 1885. Artillery of the United States. Ericsson's submarine cannon. Trials of torpedo boats for the English Navy. The Russian Navy. French Navy. Torpedo boats for Chinese waters.

Nos. 2 and 3. Tactics of torpedo boats (trans.). Retrospect of maritime law and legislation, 1884 and 1885 (end). Magnetic observations, by Professor Gelcich. Illuminants for lighthouses. Notes on torpedo boats of the English, French and Spanish Navies. New vessels for the French Navy. Budget of the Russian Navy for 1886. The yachts Puritan and Genesta. Cruise of the Austrian corvette Hilgoland on the west coast of Africa in the years 1884 and 1885.

This volume contains much important information, commercial and otherwise, in reference to most of the West African ports, as well as to the Canary and Cape de Verde Islands. J. T. S.

NORTHEAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.

VOL. II., 1885. On the application of hydraulic pressure to the driving of machines, by Mr. R. H. Tweddell. On the construction and fittings of salvage steamers, by Mr. Otto Ullstrom. On the stiffening of collision bulkheads, by Mr. M. C. James. Forced draught, by Jas. Pattison and Magnus Sandison. J. K. B.

PROCEEDINGS OF THE SOCIÉTÉ DES INGÉNIEURS CIVILS.

OCTOBER, 1885. Trials of a steam engine constructed on the Quêruel system.

Floating dock at Rotterdam.

Built of iron, in two parts, each forming a distinct and separate dock complete in itself; one 90 m., the other 48 m. long. Exclusive of their own weight, the larger dock can raise 4000 tons, and the smaller dock about 2000 tons. Both docks can be emptied in two hours.

NOVEMBER, 1885. The use of dynamite in large mining operations. Mutual forces and their application to mechanical, physical, and chemical phenomena. Marine exhibit of Belgium, France, England, Holland, Italy and Germany, at the Antwerp International Exposition. Outlines of an international language proposed by Mr. Maldant. Remarks by Mr. Kerckhoffs in favor of "Volapük."

DECEMBER, 1885. Employment of dynamite for the blowing up of large mines (plate). Experiments with indicators on locomotives.

Cannon tubes of Martin steel unhammered.

Composed of first-choice material, cast iron, waste forged iron, and a little ferromanganese containing silicon, treated by the Martin process. The steel obtained is absolutely without bubbles; it is reheated and allowed to cool in powdered coal: this rectifies the interior tensions and imparts high elasticity and resistance. Breaking strain 61 kilog. (134 pounds), with increase of length of 13 per cent.; elastic limit 22 kilog. (48.4 pounds), and diminution of section of rupture 14.4 per cent.

Cannons of 8.4 cm. (3.3 inches) thus manufactured have endured 2000 fires with service charges without injury or enlargement of the powder chamber.

E. B. B.

RIVISTA DI ARTIGLERIA E GENIO.

DECEMBER, 1885. A mountain howitzer carriage. Rifle practice. The Spezia experiments of October, 1884.

JANUARY, 1886. A summary of contents for the years 1884, 1885. The Flood Rock explosion. Gen. Thayer's system of aërial navigation.

FEBRUARY, 1886. Translation of No. 31 of the Naval Institute Proceedings (Report of the Gun Foundry Board). Italian military balloons.

MARCH, 1886. Translation of No. 31 Naval Institute, continued. Formulae for indirect fire. R. C. S.

RIVISTA MARITTIMA.

DECEMBER, 1885. Hydrographic work by the Vettore Pisani: Patagonia, Chili, the Galapagos and Philippine Islands, 1882–1885. The battle of Ecnomus. The Italian Navy estimates.

MARCH, 1886. Navigation notes from the cruise of the Vettore Pisani, continued. Italian Navy estimates. Report of the Fortifications Board, translated. R. C. S.

REVUE MARITIME ET COLONIALE.

MARCH, 1886. The ports of Tonquin. Cyclone off Cape Horn. Central administration (Navy Department) of the Navy and of the Colonies. Liquid fuel. Stockless anchor. The lighting of lighthouses by electricity.

APRIL, 1886. Report of Lieutenant Le Roy of the passage from Brest to Toulon of Torpedo Boat No. 61. Finished or projected works upon the English Channel and North Sea harbors, and the influence they may exert upon the coast.

Hurricane in the Gulf of Aden, June, 1885.

Exceptional, owing to its terrific violence; the few instances known of a similar tempest in the Gulf; the fact of its course being from east to west; the diminution of its diameter as it advanced up the Gulf, contrary to all previous observations; and the total failure of the barometer to announce its coming.

The tides of the Charente. Atlantic currents.

Copper spheres, barrels and bottles, with suitable inscriptions in several languages, sealed up in glass phials, were put over at regular intervals from the Prince of Monaco's yacht Hirondelle, upon a line 170 miles long, running about north 14° west. Ten spheres, 20 barrels, and 149 bottles were put over. Two bottles, 1 barrel, and 2 spheres have been recovered. Although nothing conclusive has been established, the drift of the recovered objects tends to show that no water from the southward of 42° N. reaches the coast of France; going to prove the object of the investigation—that the climate of the French Atlantic Coast is not influenced by the Gulf Stream.

MAY, 1886. Historical studies on the French Navy. Determination of currents by four altitudes taken at intervals.

Japanese cruiser Unébi.

Launched April 6th, at Havre. Built by Mr. Marmiesse. Length between perpendiculars, 321 ft. 3 in. (98 m.); draught (mean), 18 ft. 9.3 in. (5.72 m.); displacement, 3700 tons. Armored deck extending the whole length of the vessel. Divided above the armored deck into 57 compartments, separated by cofferdams formed of bulkheads, 17.71 in. (45 cm.) apart, and filled in with cork; the cofferdams also are divided into 40 compartments. Hull entirely of steel. Armament, 4 9.44-in. (24 c.) Krupp guns in half turrets, 170° train, 6 5.9-in. (15c.) Krupp in broadside and of the same calibre as a chase gun, all mounted on central-pivot Vavasseur-Canet carriages, built at Havre. In addition 2 6-lb. and rapid-firing Nordenfelts, 10 Nordenfelt mitrailleuses (4 barrels 25 mm.), and four Gatlings (new model), and four torpedo-discharging tubes. Ammunition giving 110 fires for the larger guns, and 4000 for the smaller. Estimated speed 17½ knots. Twin screws, each worked by independent engines; total horse-power 6000, with ordinary capacity to steam 5600 miles at

10 knots; by the addition of 200 tons, which can be done easily, she can steam at this speed 8000 miles. Barque-rigged. Fitted with a steam capstan capable of working all four chains, and two hoisting windlasses for ordinary deck work. Below the armored deck she is divided into 29 compartments. Crew 280 men.

Notes and observations by Lieut. M. E. Perrin, French Navy.
New Italian torpedo boats.

There are 24 of various types actually constructing, raising the number to 83.

E. B. B.

UNITED SERVICE GAZETTE.

FEBRUARY 13, 1886.

Admiral Aube, the French Minister of Marine, has decided to detach the torpedo service in each French port from the other branches of the harbor defense, and to place it under the supreme command of either a captain or a lieutenant in the Navy, according to the importance of the place.

FEBRUARY 20.

The Italian Admiralty have provided for the construction of twenty-eight torpedo boats of different types, all of which are to be built in Italy.

The Anson, a twin-screw armor-plated barbette ship, was launched February 17th, at Pembroke. The principal dimensions are: Length between perpendiculars, 330 feet; extreme breadth, 68½ feet; displacement, 10,000 tons; engines, 9500 H. P., and indicated speed, 16 knots. The belted armor will be 18 inches thick; she will carry four 64-ton guns, six 6-in. broadsides, 10 Nordenfelts, and 12 quick-firing guns; her complement of officers and men is 430.

FEBRUARY 27.

According to the *Marine Zeitung*, of Vienna, the German fleet at present consists of 13 ironclads, 14 armored gunboats, 9 armored frigates, 11 cruising corvettes, 5 unarmored cruisers, 4 unarmored gunboats, 8 dispatch vessels, 11 harbor-defense vessels, and 10 pilot ships; in all, 97 vessels, with 558 guns, 180,117 tons, 163,005 I. H. P., and 16,682 men.

MARCH 13.

The French Minister of Marine has recently tested the navigability of torpedo boats and their action in discharging their projectiles. The boats were sent from Cherbourg around by Gibraltar to Toulon. While their sea-going qualities in bad weather are excellent, the vibration, want of fresh air and lack of comfort are such that the crews cannot endure more than thirty-six hours of continuous navigation, when they must have rest or be relieved. On the other hand, the projectiles worked admirably. While the Admiral Duperré was steaming in fine weather at a speed of 14 knots, two stationary boats discharged six torpedoes at different angles, and all struck and exploded. The Duperré, steaming 14½ knots, was again struck twice by torpedoes from boats going in the opposite direction at a speed of 9 and 12 knots, the discharges being made at a distance of about 500 yards. From observation on board the Duperré, it was found that the projectiles were totally unaffected by the wash of the ship.

APRIL 3.

According to the *Marine Zeitung*, the torpedo organization of the German service is, in order to render it more efficient, to be placed under the charge of a "Torpedo Inspection," with headquarters at Kiel. The Inspector-in-Chief will decide on all matters connected with the construction and equipment of the boats, training of their crews, laying of submarine mines, and the general torpedo defense of harbors. He will, however, have no authority over boats attached to a squadron.

APRIL 17.

On March 24th, an obsolete armored vessel, the Armide, was towed to sea in the Juan Gulf and allowed to drift as a target for the French Mediterranean squadron, which fired at her while steaming at ranges of 3000, 4000 and 5000 metres, with 24, 27 and 32 cm. guns. In time the hull resembled a colander, and the vessel would have sunk had she not been filled with casks.

The Spanish Government has contracted for two first-class Yarrow torpedo boats of the Falke type, to have a speed of 23 knots fully equipped and 25 knots an hour light.

There are now 1173 guns in course of construction for the English Navy, 557 being for armored, 109 for protected, and 507 for unprotected. Of this total there are 5 110-ton and 18 66-ton; the rest are of smaller calibre, among which are 182 5-ton guns, 177 6-pounder Nordenfelt and Hotchkiss, 264 3-pounder Hotchkiss, 97 1-inch 4-barrel, 151 1-inch 2-barrel, 62 0.45-inch 5-barrel Nordenfelts, and 56 0.45-inch 5 and 2-barrel Gardners.

The Amphion.*

She has two 2-barrel Gardners in maintop and in the mizzen, and one Nordenfelt in the foretop. Under the forecastle and poop are two 4-barrel 1-inch Nordenfelts; there are two torpedo tubes on each of the lower decks. A fieldpiece is mounted on the poop, and it is intended to supply two 5-barrel Nordenfelts for tops and boats. The gun trials proved satisfactory. The ship, however, did not show much stability; in going about she rolled considerably and heeled 17°.

Regulations for training leading stokers and stokers in the use of arms and in the management of the machinery and boilers of torpedo boats.

The English Admiralty have issued a series of instructions in regard to the engineer force, in which it is provided that all stokers are to receive instruction in rifle, cutlass and pistol drill; second-class stokers not to be rated stokers without a fair knowledge of these drills; stokers to be trained in working of torpedo-boat boilers and machinery, and when qualified in this and in drills to be rated trained men and to receive 1d. a day extra pay; trained men to receive extra pay when on regular torpedo duty. The instructions also provide in details for the torpedo-boat exercises and for the qualification of the trained men.

MAY 1.

A new fast cruiser is to be built in Kiel to replace the German wooden corvette Ariadne. She is to be built on the cellular system, to have an armored deck, and to make 18 knots. Another similar vessel, the Elisabeth, is now building at Stettin.

At the trial of the Haytian gunboat *Toussaint l'Ouverture*, built at Havre, 13½ knots speed was attained; she is to carry two 12-cm. guns, arranged to deliver a fore and aft fire, and 16-cm. gun forward.

The Grasshopper, the first of a newly designed class of steel gun and torpedo vessels, is building at Sheerness. She will be 200 feet long, 23 feet beam, 6 feet 6 inches draught forward, and 9 feet 6 inches aft, and will have a speed of 19 knots in a rough sea. The armament is to consist of B. L. R., Gardner and Nordenfelt guns, and four torpedo tubes.

MAY 8. "Another gun burst."

On the 4th instant, a 43-ton gun burst on board the Collingwood, fortunately without injury to any one. The vessel left Portsmouth in the morning to try

*Nav. Inst. Proc. **11**, 830.

the Vavasseur mountings of her after pair of 43-ton guns. Six rounds were to be fired from each, two with reduced charges of 221¼ pounds of cocoa powder, and four with full charges of 295 pounds. The projectile was a common shell weighing 714 pounds, filled with water. A scaling charge of 73¾ pounds was first fired from each gun to clear the rifling of any possible obstruction. The right gun was then fired with the reduced charge of 221¾ pounds; upon firing the left gun with the same charge it exploded, the separation occurring at the forward rim of the B_3 coil.

The smoke of the explosion had so completely stained the face of the fracture that it was impossible, on a cursory survey, to observe any flaws or defects in the manufacture. The cleavage was exceedingly jagged, some of the rents showing that the core at the spot had been torn away from the hoop as from a socket. About six inches from the point of fracture, the outer coil itself had been riven entirely round. This circular rent was about one inch in diameter, and extended through the jacket to the steel core of the gun, appearing as if the weld of the coil had been torn open at the moment of separation. The damage to the ship was considerable. Some of the fragments ploughed up the deck; the armored top and grate of the neighboring scuttle were smashed, the ladder to the barbette gallery was torn away, and the glacis plates deeply indented. The hinges of the armored door of the bulkhead were fractured; the shelter screen at the flying deck was bulged in and penetrated; the adjoining Gardner machine gun was broken and dismounted, and the face of the reflector was completely splintered. The entire muzzle of the gun, which was unprotected by sheet coiling, was blown away, leaving a deep fissure between the cylinder and the last coil. C. B.

SPECIAL NOTICE.

NAVAL INSTITUTE PRIZE ESSAY, 1887.

A prize of one hundred dollars and a gold medal is offered by the Naval Institute for the best Essay presented, subject to the following rules:

1. Competition for the Prize is open to all members, Regular, Life, Honorary, and Associate, and to all persons entitled to become members, provided such membership be completed before the submission of the Essay. Members whose dues are two years in arrears are not eligible to compete for the Prize until their dues are paid.

2. Each competitor to send his essay in a sealed envelope to the Secretary and Treasurer on or before January 1, 1887. The name of the writer shall not be given in this envelope, but instead thereof a motto. Accompanying the essay a separate sealed envelope will be sent to the Secretary and Treasurer, with the motto on the outside and writer's name and motto inside. This envelope is not to be opened until after the decision of the Judges.

3. The Judges to be three gentlemen of eminent professional attainments (to be selected by the Board of Control), who will be requested to designate the essay, if any, worthy of the Prize, and, also, those deserving honorable mention, in the order of their merit.

4. The successful essay to be published in the Proceedings of the Institute; and the essays of other competitors, receiving honorable mention, to be published also, at the discretion of the Board of Control; and no change shall be made in the text of any competitive essay, published in the Proceedings of the Institute, after it leaves the hands of the Judges.

5. Any essay not having received honorable mention, to be published only with the consent of the author.

6. The subject for the Prize Essay is, *The Naval Brigade: Its Organization, Equipment, and Tactics.*

7. The successful competitor will be made a Life Member of the Institute.

8. In the event of the Prize being awarded to the winner of a previous year, a gold clasp, suitably engraved, will be given in lieu of a gold medal.

By direction of Board of Control.

JNO. W. DANENHOWER,

Lieutenant, Secretary and Treasurer.

ANNAPOLIS, MD., *January* 1, 1886.

NOTICE.

At a meeting of the Board of Control on June 2, 1886, by virtue of Section 4, Article V. of the Constitution, Commander P. F. Harrington, U. S. N., and Lieutenant B. F. Tilley, U. S. N., were elected members of the Board of Control, to fill the vacancies caused by the resignations of Commander N. H. Farquhar, U. S. N., and Professor Chas. E. Munroe, S. B., by reason of detachment from the U. S. Naval Academy.

At the meeting of June 7, 1886, the following resolution was unanimously adopted:

Resolved, That a vote of thanks be tendered to Professor Chas. E. Munroe, S. B., as an expression of appreciation of his important services to the Naval Institute during the past ten years. He became a member of the Board of Control at its organization, and he has at various times filled the offices of Secretary and Treasurer and Corresponding Secretary. He has made numerous contributions to the Proceedings, especially in the valuable "Notes on the Literature of Explosives," which have attracted the attention of the chemists of Europe and America.

That the Institute regrets Professor Munroe's departure from this Station.

By direction of the Board of Control.

JNO. W. DANENHOWER,

Lieutenant, Secretary and Treasurer.

Vol. XII., No. 4. 1886. Whole No. 39.

PROCEEDINGS

OF THE

UNITED STATES

NAVAL INSTITUTE.

VOLUME XII.

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BALTIMORE, MD.

THE PROCEEDINGS

OF THE

UNITED STATES NAVAL INSTITUTE.

Vol. XII., No. 4. 1886. Whole No. 39.

U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

APRIL 20, 1886.

COMMANDER HORACE ELMER, U. S. N., in the Chair.

RANGE LIGHTS ON SEAGOING SHIPS.

BY LIEUTENANT F. F. FLETCHER, U. S. N.

The necessity of changing the present system of lighting ships has long been apparent, and is growing more urgent every day, owing to the constant increase of ocean travel. It is no longer sufficient simply to know that a red light to starboard, or a green light to port, indicates the position of a vessel heading in such an indefinite direction that she may, or may not, be crossing your course. For safety in navigation something more definite is demanded. With the great speed of modern steamers, ships must be lighted so that their course and movements may be shown at night with as much accuracy, if possible, as during the day. In devising means to accomplish this object it must be borne in mind that, when emergencies arise, the memory is not always to be depended upon, and any system of signals requiring the mind, under such circumstances, to reason from cause to effect will always be more or less unreliable. Even with the present side lights it is only after long experience, upon sighting a colored light, that one remembers, without reflection, that red means

port and green starboard, and thus forms a mental picture of a ship in the position indicated by the light. If, in addition to the colored light, signals are made, the meaning of these signals must also be recalled to memory; and when they indicate a change of helm or movement of the vessel, the effect which follows them, not being visible to the eye, must be applied to the mental picture already formed. Thus, under the influence that an unseen danger inspires, and with confusing data to bear in mind, errors will inevitably occur.

It is sought to reduce to a minimum the mental process by which the heading and the movements of a ship are determined, thus leaving the judgment unembarrassed. The necessity of forming a mental picture must be avoided and the unseen danger brought plainly in view. The proposition to place two lights on each side of a ship is a step in this direction, but it is doubtful that the small advantages obtained by any of these systems are sufficient to outweigh the disadvantages of carrying two additional lights.

To avoid collision successfully under all circumstances there is required: 1. The position of your vessel in regard to the heading of the other; 2. Any change of that vessel's course; 3. Her approximate speed. By day the heading of a ship and change of her course are indicated by the appearance of her masts and hull, and the speed is estimated from the character of the vessel and the rapidity with which her bearing changes; but at night these conditions must be shown by means of lights. The idea involved in the following proposed system is to so place three lights on a ship that she will be lighted all around the horizon, and her heading and every change of her course will be more plainly indicated at night by means of these lights than is indicated during the day by the appearance of the ship itself. We shall first consider the system in its simplest form, and then such modifications as may be deemed necessary to accomplish the desired object.

Lights.

1. Every seagoing ship, whether a sailing ship or a steamship, shall carry, forward of the foremast, two bright white lights of the same character as the present masthead light of steamships, visible five miles on a clear night, and showing an unbroken light from right ahead to two points abaft each beam. These two lights shall be in the vertical plane of the keel, and placed with the lower light forward of the upper light, so that for a vertical distance of ten (10) feet

between the lights there will be a horizontal distance of fourteen (14) feet, or in the proportion thereof—*i. e.*, a line through the two lights will make an angle of fifty-five (55°) degrees with the vertical.

2. Every seagoing ship, whether a sailing ship or a steamship, shall carry at the stern one bright white light so fixed as to show an unbroken light from right astern to two points forward of each beam. With lights placed as above, the direction in which any ship is heading, and every change of that direction, will be plainly indicated by the relative position of the two forward lights, as will be seen by the following explanation.

When right ahead of another ship, her two forward white lights will be seen, one directly above the other. On the starboard bow of that vessel her lower light will be open to the right of her upper light, and on her port bow her lower light will be open to the left of her upper light—*i. e.*, on her starboard bow an imaginary line through her two lights will incline to the left from the vertical, and on her port bow it will incline to the right from the vertical. The amount of the inclination of the lights of that vessel from the vertical indicates your position on her bow; thus: From right ahead her lights will be seen in a vertical line.

1 point on her bow their inclination will be					1½	points	(15° 25′).
2 points	"	"	"	"	2½	"	(28° 25′).
3 "	"	"	"	"	3½	"	(39° 22′).
4 "	"	"	"	"	4	"	(45°).

To estimate the inclination of the lights by the eye to within 11° (one point of inclination), or even more, is quite accurate enough for all practical purposes. We may therefore disregard the fractional parts of a point in estimating the inclination of the lights. Then, your bearing on the bow of any vessel will be the same as the number of points the lights of that vessel are inclined from the vertical. If you bear more than four points on the bow of another vessel, the lights of that vessel will be inclined more than four points, or 45°. At six points on that vessel's bow her stern light will be visible. If you bear between two points forward of her beam and two points abaft her beam, her two forward lights and her one stern light will be visible. From two points abaft the beam on one side to two points abaft the beam on the other side, the stern light alone of that vessel will be visible. The diagram, Fig. 1, illustrates through what arcs the lights of any vessel will show, and how much a line joining the two forward lights will appear inclined from the vertical at different positions on her bow.

When two vessels are meeting end on, each will see the lights of the other in a vertical line, so that any change of the course, or of the bearing, may be instantly detected by observing that the lower light opens to the right or left of the upper light. When two vessels are crossing, each ship will see the lights of the other inclined from the vertical. *C* being two points on the port bow of *D*, he will see two white lights on *D* inclined about two points to the right from the vertical. *D* being four points on the starboard bow of *C*, he will see two white lights on *C* inclined four points (45°) to the left from the vertical. From two points forward of the beam to two points abaft the beam, on both sides, all three of the lights will be visible.

To test the practical working of this system, lights were placed in position on a steam launch. At a distance when the lights were just visible and with but eight feet in the vertical between them, the heading of the launch was plainly indicated, and every change of course was at once easily detected. At given signals made by occultations of the light, four observers on the ship estimated independently the heading of the launch. Of over fifty observations on various courses the greatest single error was but one and one-half points, part of which was, no doubt, due to the error of the boat's compass, which was not ascertained. Lights were also placed in position on the ship, and three observers in the launch steamed around at a distance varying from one-half to one mile. Bearings of the launch were accurately taken from the ship, and the result is tabulated below.

Bearings of the Launch on the Ship's Bow.	Estimated Position by Observers in the Launch.	Personal Errors.	Average Error.
55° starboard bow.	48 50 52	7° 5° 3°	½ point.
50° " "	45 40 45	5° 10° 5°	½ "
43° " "	45 30 35	2° 3° 8°	¼ "
25° " "	30 30 20	5° 5° 5°	½ "
6° " "	2 2 2	4° 4° 4°	½ "
21° port "	15 10 15	6° 11? 6°	¾ "
31° " "	40 40 30	9° 9° 1°	½ "
39° " "	40 35 37	1° 4° 2°	¼ "
43° " "	40 40 40	3° 3° 3°	¼ "
50° " "	50 50 50	0° 0° 0°	0 "

Speed signals were also made, and nothing simpler or plainer could be desired. Although these experiments were not made in rough

water, they will serve to show the accuracy of the range under ordinary circumstances.

It may be urged, as an objection to this system of lighting ships, that the rolling or heeling of a ship in a seaway will destroy the range of her lights. In answering this objection, it is necessary to investigate the effect upon the apparent inclination of the lights caused by any motion of the ship. If a ship rolls regularly through equal arcs on each side of the vertical, the angle may still be estimated with sufficient accuracy by noting the centre of the arc through which the lights move. As the motion of the waves and the rolling of the ship are not uniform, there frequently occur intervals when their effect is neutralized and the ship becomes momentarily upright. It requires but little observation to detect these intervals. But any permanent or steady heel will more seriously affect the apparent inclination of the lights than the same amount of rolling. We will first consider the effect upon this inclination when the vessel heels from you or to leeward. Any heeling towards you will apparently place you farther on her bow, but not sufficiently to be misleading.

In the diagram, Fig. 2, A represents the apparent position of the upper light, and B the apparent position of the lower light, when seen from directly ahead. B_1, B_2, B_3, B_4, B_5, and B_6, the apparent position of the lower light when seen from one, two, three, four, and five points on the bow, and abeam ; the upper light still appearing at A. A_a, A_1, A_2, A_3, A_4, and A_5, the arcs through which the light A appears to move while the ship heels through 90° when seen from ahead, one, two, three, four, and five points on the bow. The lines AB, AB_2, etc., represent the apparent inclination of the lights when seen from one, two, etc., points on the bow. To find this inclination when the ship is heeled, draw a line through the apparent position of the lower light to the point in the corresponding arc to which the upper light is heeled. Thus, when you are three points on the bow of a ship heeled twenty-five degrees, the apparent inclination will be B_3L instead of B_3A.* In this way it will be seen that when you are six points on a vessel's bow, no matter how much she may roll, her lights can never indicate that you are less than five points on her bow. At five points on her bow her lights can never indicate that you are less than four points. At four points her lights can never make a less inclination than 35° from the vertical, which corresponds to a position of three points on her bow. At three points an improbable steady heel of 25° will still leave the lights inclined 25°,

which corresponds to a position two points on the bow. At two points she will have to be heeled over 35° before the lights will indicate that you are ahead. If she rolls 35° to leeward, or from you, and nothing to windward—an extreme case—her lights will still plainly indicate that you are more than one point on her bow. We see, then, that at two, three, four, five, and six points on a vessel's bow it will hardly be possible to make an error of more than one point due to any heeling or rolling of the ship.

With the present system of lighting ships the colored side lights generally show one-half a point on the opposite bow, and, through carelessness, often more. There is, then, a sector ahead of ships comprised between one-half a point on each bow, within which you cannot tell which bow you are on. This corresponds to the position, under the law, of "end on or nearly end on." No evil effects result from the lights shining across the bow to this limited extent. Knowing that you are in this doubtful sector defines your position with sufficient accuracy to avoid collision. It now remains to determine this "doubtful sector" with the range lights. First, in the case of steamers: during light breezes and a smooth sea there is practically no doubtful sector. With moderate breezes and a moderately rough sea it will be less than that assigned to the colored side lights. In rough weather, when a steamer is rolling heavily, if the average inclination of her lights be estimated with but a fair degree of accuracy, it will still be small. Thus, if you are ahead, and she is rolling as much as sixteen degrees to leeward and nothing to windward, twenty degrees to leeward and but five to windward, etc., you may know from the average inclination that you are within half a point on her bow. Again, if you are one-half a point, say, on her weather bow, she will have to roll more than thirty degrees to leeward and nothing to windward, or maintain a steady, permanent heel of sixteen degrees, before her lights will indicate that you are one-half a point on the opposite bow. Some seagoing steamers cannot maintain a steady heel of more than six or seven degrees, owing to the danger from parts of the boiler becoming unduly heated. It is doubtful if any ship will have occasion to steam along at night with a greater steady heel than ten or twelve degrees. But attention is called to the fact that when a vessel is thus heeling, the cause is evident in the state of the wind and sea, and it requires but little exercise of the judgment to make all necessary allowance for such a case and accordingly act with a greater margin of safety. The same remarks apply to sailing vessels,

and, although the heeling may be more, the amount of the heeling is more evident and certain. If, with a beam wind and sea, you are meeting nearly end on, your true position is to windward of your apparent position by an amount equal to the heel of the ship. For simplicity, assume this amount to be constant and equal to one-half a point in all cases where a vessel should be heeled on account of wind or sea. Then, if extreme heeling causes an error of one point in judging your position (and it can scarcely cause more), you will be but one-half a point from your true position. If you have assumed an extreme heel, and corrected your position accordingly, when in reality no heel existed, you will still be but half a point from your true position.

It has been assumed that the simplicity and evident advantages of carrying but two bright white lights, and the accuracy obtained by their range under all ordinary circumstances, will far outweigh the chances of a possible error under exceptional circumstances. If such does not prove to be the case, there is a simple and effectual remedy that will be shown further on.

Any radical change in the present system of lighting ships meets with the serious and well-founded objection that its introduction, no matter how much of an improvement on the old system, will cause confusion and lead to grave disasters. No such difficulty need be met with in the introduction of the proposed system. The principal steamship lines may be authorized to carry their spare masthead light so that the two will form the assigned range, while the colored side lights are still retained. As the value of the range lights becomes recognized, and their use becomes familiar (their simplicity requiring but one practical demonstration to make them so), the colored side lights may be discontinued. If, after thus giving the system a fair practical trial upon the ocean under all conditions of wind and sea, it is found that the range does not sufficiently define your position in the doubtful sector ahead, the defect can be fully overcome by retaining the side lights. If, then, extreme heeling should cause any doubt as to your position when nearly ahead, you will know that you are within a point or so on that bow of the ship shown by the color of her side light. Such an arrangement requires four lights, but the same result will be obtained by combining the two side lights and the lower white range light into one light fitted with a centre screen so as to show green to starboard and red to port. As the stern light is not absolutely necessary, we shall then have all ships lighted by only two

lights—a white masthead light and a lower colored range light. This is practically no change in the present system of lighting ships. It simply amounts to placing the two side lights on a range with a masthead light. The color of the light performs no part in determining the heading of a ship, but simply serves as a check in estimating your position under exceptional circumstances.

In avoiding collision, owing to the great speed of some modern steamers and the comparatively slow speed of others, speed has become quite as important a factor as the heading or the bearing of a ship. Thus, suppose that from a steamer with a speed of eighteen knots the lights of a steamer with a speed of seven knots are sighted, close by, between three and four points on the starboard bow. The first vessel must keep clear, and her safest way is to keep her course and maintain her speed, while to port the helm or to slow down and attempt to pass astern might be dangerous. Again, suppose the case reversed and the slower steamer sights the faster one five points or even more on her starboard bow; the slower steamer may not be able to pass ahead of the faster one, and yet, not knowing the speed of the latter, she would be justified in attempting it. The same illustration applies when considering the relative heading of another ship.

If the speed of all vessels were the same, there would be but two factors to consider—a vessel's heading and her relative bearing—so that the avoidance of collision could be reduced to a mathematical rule so simple in its practical application as to be almost independent of errors of judgment. But when the third factor of a difference of speed has to be taken into consideration, the problem becomes so complicated that no practical rules can be made applicable to all cases. Such general rules do more harm than good by often lawfully justifying a course which one's judgment regards as dangerous. This was plainly demonstrated by what was known as the "law of the port helm," where the port helm was indiscriminately resorted to in cases of doubt, not so much with the object of avoiding collision as to clear the owner of responsibility. The most that can be done is to furnish at a glance the correct data as to the bearing, heading, and speed of a ship, and then indicate, as the present law does, which vessel shall keep clear of the other.

The most obvious method of indicating a vessel's speed at night is by means of signals, and these signals, like the lights, should be continuous and mechanical in character, and not subject to personal error or negligence in making them. The following means by which this

may be accomplished may appear, upon first thought, to be complicated, but will be found to be simple and practicable, and of invaluable utility for other purposes.

The upper light on steamships is to be so fitted with a guard surrounding the flame that the light will be occulted every half minute a given number of times according to the speed; each occultation lasting one second, with an interval of one second, and the number of occultations to be regulated as follows:

Speed 5 knots, or nearest thereto, 1 occultation every ½ minute.

Speed 10 knots, or nearest thereto, 2 occultations every ½ minute.

Speed 15 knots, or nearest thereto, 3 occultations every ½ minute.

Speed 20 knots, or nearest thereto, 4 occultations every ½ minute.

That is, one occultation for every five knots of speed. The mechanism required to make these occultations may be of the simplest character, occupying but a few inches of space within the lamp. It will cost much less than the lamp itself, and, being less delicate, can withstand rougher usage without injury. It will not be required to keep accurate time, since an error of even ten or fifteen seconds a minute will make no difference in the result. As electrical appliances are now almost universal on board steamers, a small armature and magnet may be placed within the lamp, and the wires led to the bridge or pilot house. There they will be connected with the clock mechanism which completes the circuit the required number of times every half minute, making the occultation as required above. The number of occultations is then under immediate control. By means of a switch and a make-circuit key the speed signals may be discontinued and long and short occultations made according to a devised code of signals. Ships would thus be enabled to communicate with each other at night. Messages could be exchanged by passing steamers, even though their decks were below the horizon, at such distances that flag signals would be invisible. The international signal book would become as useful at night as during the day, and telegraphic signals could be exchanged more rapidly. A rope or stay passing in front of the light will not occult it, and if temporarily obscured by a yard or sail during a heavy roll, the effect would be so entirely different in its character that it could not be confounded with speed signals. The bright white lower range light, powerful enough to be seen ten or fifteen miles, could scarcely be mistaken for a deck lantern or cabin light accidentally exposed. If such were the case, the evil could easily be remedied by occulting the lower light for

speed signals instead of the upper one. In the case of sailing vessels, this possible objection will be considered further on.

The speed of sailing vessels is indicated with sufficient accuracy by the force of the wind. The speed occultations of a steamer's light will, therefore, distinguish her from a sailing vessel.

The present masthead light of nearly all steamers is now carried upon one of the forward stays, and there can be no difficulty in placing the two range lights in their relative positions. The lights can also be readily placed upon sailing vessels, showing clear of all the head sails, and without altering any of the rig. Thus, beneath the foot of the topgallant sail, or royal, or even at the masthead, are positions more suitable than that occupied by many masthead lights at present, which are so low as often to be obscured by sails. If no position on the mast or headstays is found suitable, the light can be placed on a span running fore and aft across the headstays and above the sails. A secure position, making the required angle, can always be found for the lower light beneath the headbooms or on the outer stay. The number of lights required to be carried by seagoing ships may be further reduced: 1. A ship towing another ship shall carry a bright white light similar in character and construction to the masthead light, and placed in the line of the range lights, not nearer than five feet to either of them; 2. A ship not under command shall carry a red light in place of the additional light carried by towing ships, the light to be visible over the same arcs and visible at least two miles; 3. A ship employed in laying or picking up a telegraph cable shall carry a green light in place of the additional light carried by towing ships. When not making headway the ships referred to in 2 and 3 shall not carry the upper white light. As the system now stands, it may be said that it can never be misleading; the objection to colored side lights, except their lack of power, is almost entirely overcome; the number of lights is reduced to a minimum; the speed is indicated and your position determined with all necessary accuracy; all of which may be comprehended at a glance. If this system does not fulfill all the conditions required, it is hoped that its discussion may continue to agitate the problem of lighting ships to avoid collision, and help to arrive at some satisfactory solution.

DISCUSSION.

Lieutenant CHARLES BELKNAP.—*Mr. Chairman and Gentlemen:*—I have listened with a great deal of interest to this paper, for I, with many others, believe that the present system of showing a vessel's position by lights is inadequate to the needs. The plan proposed by Lieutenant Fletcher is ingenious, and admirable in many respects; I do not, however, think that the forward light could be carried by schooners and other vessels of low freeboard in bad weather with any degree of security. Even if they did not, it would not, perhaps, be very different from their common practice at present. But Lieutenant Fletcher makes no distinction between sailing vessels and ordinary steamers, and this I look upon as a serious defect; on the other hand, the plan seems admirably adapted to the use of steamers, especially in a crowded harbor like New York's, and it affords, moreover, an opportunity of getting rid of the green light—a very strong point in its favor.

Lieutenant C. D. GALLOWAY.—*Mr. Chairman and Gentlemen:*—The system of lights suggested by the essayist seems to me to be one possessing many favorable points. That it is a good one in principle is conclusively proved by its successful use by steamers in all of our inland waters; that it could be applied successfully to seagoing vessels there seems to be little doubt. The angle at which they should be placed, as so fully worked out by the essayist, appears to be a very important point in the system.

When the essayist suggests that with his scheme the rule of the road varies with the speed of either vessel, I think he makes a grave mistake. There are so many reasons why the speed of any vessel may vary suddenly and unexpectedly. No variation in the rules should be permitted unless the approaching vessel is in sight long enough for several bearings to be taken, and she be found to be drawing aft or becoming more distant.

As to the determination of speed by flashes, an error of one count in the number of flashes may make an error in speed information of five knots. The most likely place for collisions being at points where many vessels arrive at or about the same time, imagine the officer of the watch with two or three steamers and as many schooners and other sail vessels in sight counting the flashes of each steamer, remembering the knots for each, looking out for his own vessel, and considering whether the rules of the road should be observed literally, or if, in his judgment, the speeds of the approaching vessels warrant a personal departure. I cannot see that this requires further comment. The occulting light for signals, however, might be useful.

The essayist says the lights are to have a range of 5 miles on a clear night, and, in his remarks on the system of occulting, he says the lower light, if powerful enough to be seen 10 or 15 miles, would not be mistaken for any deck light, etc. No light can be placed as low as required by the system and have such a range; it is doubtful whether a 5-mile range could be reached except in a few vessels with exceptionally high freeboard, nor do I think such a range would at all enhance the value of the system.

Referring again to the essayist's remarks on speed, he says that the speed of sail vessels can be calculated by the force of wind ; this I have no hesitation in saying is totally unreliable. As with steamers it is not possible to tell, under many conditions of sea and wind, the heading within one or two points, owing to the heel of vessel affecting angle of lights, so, with sail vessels, it will certainly be impossible to tell even the approximate speed by knowing only her approximate heading. So many unknown quantities enter this problem—the rig of the vessel sighted ; whether a good model or a bad one ; whether light or deep-loaded ; whether she has all drawing sail set, or is under easy or jury canvas ; whether by the wind or free. A consideration of this impresses me more forcibly that any rule of the road involving speed is radically wrong.

I presume the essayist intends that the occulting of the upper light shall be the distinguishing mark for steam vessels, although he does not say so. I think a colored light—say red—would be much more effective. I say red in preference to any other color, as it is less liable to be mistaken for any other; cheap green shades frequently appear white. And again it is doubtful whether any method of occulting with certainty and precision is practicable on many small steamers, or even large ones. I think with the same lights for both, much more confusion and much greater chance of collision would ensue than with the present red and green side lights and the distinguishing white light for steamers.

The present system can be improved, and it is pleasant to think that a member of the Institute has made such a practical move in that direction. It will call forth many suggestions on the subject from men most interested in lessening the dangers of navigation, the greatest of which to-day is collision ; a danger that is increased by the gross ignorance of many seagoing people of the rules of the road, as well as by their gross carelessness in regard to the lights, which if carried at all are frequently neither properly screened nor tended. The recklessness of vessels at sea with regard to lights is known to us all. There seems to be little use of laws on the subject, as there is at present no way of ascertaining the names of vessels seen without lights. Their spars, hulls, or sails are seen and passed, with nothing to indicate even their nationality. Should a collision take place, a lamp of the proper color and size is usually produced at the trial.

The lights suggested by the essayist have the advantage of being easily carried by small vessels, even in bad weather, but with limited range, which is, however, a vast improvement over the present lamp—red on one side and green on the other—which may be flashed up suddenly under one's bows.

Again, referring to the subject of rules of the road, it is a fact that many of the masters of our fore-and-aft coasters think their vessels are on the starboard tack when their starboard sheets are aft, and *vice versa* for the port tack ; being without the tacks of square-riggers, they do not understand the proper meaning of the term. With such understanding, of what use are the rules of the road?

I should like to suggest that the pamphlet "Rules of the Road" be issued with every copy of the Hydrographic Chart, and that it be given to every master applying to branch hydrographic offices for any information. And also that

a note be added to the effect that, in interpreting these rules, a vessel is on the starboard tack when the wind blows on starboard side of said vessel, and *vice versa;* and close-hauled when sailing as near to the point from which the wind blows as possible.

While on this subject, I would like to say that in my opinion the limit of two minutes allowed for the fog signals of steamers is too great, even for the "moderate speed" at which they are required to go. For a steamer whose fair-weather speed is from 15 to 18 knots, 10 knots is "moderate speed," at which speed, between the blasts as now allowed, she will go one-third of a mile. Several methods, more or less complicated, have been suggested from time to time by which steamers may indicate their approximate course in thick weather. I would like to add one to these, as from many schemes may be devised one that will fill a long-felt want. As an approximate guide, *one* blast of the steam whistle, repeated at a not greater interval than *one* minute, indicates a course between north and east, including east; two blasts, repeated as above, indicate a course between east and south, including south; three blasts, repeated as above, indicate a course between south and west, including west; and four blasts, repeated as above, indicate a course between west and north, including north. These would no more interfere with the change-of-course signals as used by our river and bay steamers, and allowed by rules of road, than do the single blasts as at present used. This scheme, when on or near the cardinal points, still leaves much uncertainty, but is, I think, an improvement over the present guesswork.

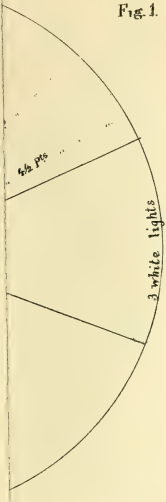
To lessen the dangers of collision, lights, of whatever system, *must* be carried in all weathers from sunset to sunrise, and the rules of the road must be implicitly obeyed.

THE CHAIRMAN.—*Gentlemen:*—I am sure we all agree as to the importance of the subject under discussion this evening. The great increase in size, unhandiness, and speed of modern passenger steamers and vessels of war has made some change in the present system absolutely necessary. The question of speed, in my opinion, is of the greatest importance, and it is the possible wide range in speed that makes some change imperative. As I listened to the reading of the paper this evening, I was strongly impressed with the fear that the essayist was attempting too much. The general discussion that followed has confirmed that impression. The principal difficulty found, however, has been in the application of this system to sailing vessels. I see no necessity for so doing, or changing the present system for sailing vessels. The distinction between the steamer and sailing vessel should be made as sharp as possible. The direction and force of the wind, in connection with the present lights, give the course and speed of sailing vessels with sufficient accuracy.

While the method proposed for indicating speed might be desirable on board of men-of-war or large passenger steamers, it does not seem to me practicable for the great majority of freight steamers. Such vessels could not be expected to have electrical experts on board; but it seems to me it might be

well to make another distinction between the high-speed steamer and the steamer of ordinary speed. All steamers making less than ten knots might carry the present masthead and side lights, all over ten knots the range lights proposed by the essayist; thus we should have three classes of vessels, the high-speed steamer, the low-speed steamer, and the sailing vessel, marked by three distinct systems of lights. On sighting a vessel's lights at night, you would be able to tell immediately whether it be a sailing vessel, a low or high-speed steamer; if the latter, the system of range lights proposed by the essayist will enable you to tell with great accuracy the course and bearing. In the other cases such close accuracy is rarely necessary. In the case of the large high-speed steamers I think the possible error from steady heel need not be considered.

Fig. 1.



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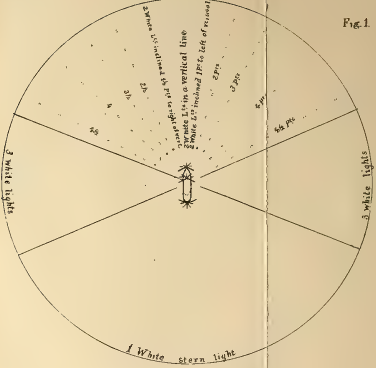
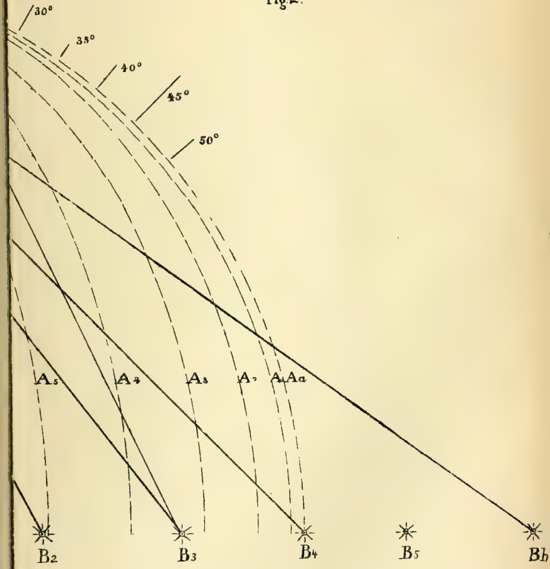

2 White Lts in a vertical line
2 White Lts inclined 1Pt to left of vertical
2 White Lts inclined 1 ½ Pts to right of vert.
2Pts
3 Pts
4½ Pts
3 white lights
3 white lights
1 White stern light

Fig. 1.

Fig. 2.



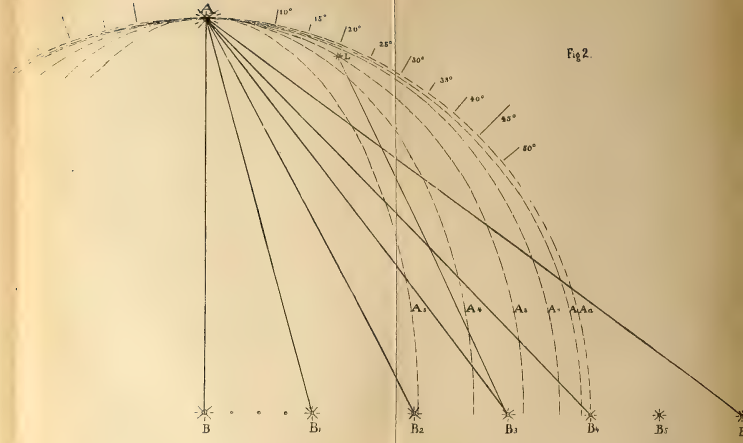


Fig 2.

A PROPOSED METHOD OF RANGING GUNS, APPLICABLE TO FLAT TRAJECTORIES.

By Naval Cadet F. W. Jenkins, U. S. N.

The angle of elevation at which a gun must be set to obtain a given range is ordinarily obtained by laying the gun at different elevations, observing the ranges and interpolating for intermediate ranges. Several shots must be fired at each degree of elevation in order to obtain a good mean range, slight variations in the conditions of fire being sufficient to make an appreciable difference in the results, so that a single shot is not to be depended upon.

The increasing cost of ammunition makes it an object to reduce the number of experimental firings as far as is consistent with accuracy. Several methods have been proposed and used in calculating trajectories, but the theoretical and experimental results do not agree as closely as can be desired. The principal reason for this discrepancy has been that the resistance of the air depends largely on the form of the head of the projectile, so that some correction must be applied to tables compiled from experimental firings to make them applicable in case a different projectile than that for which the tables are computed is used. In using Mr. Bashforth's tables this correction is made by multiplying $\frac{d^2}{w}$ by a factor, A, depending on the form of the head of the projectile, d being the diameter in inches and w the weight in pounds. The theoretical value of this constant factor A does not, however, give good results in all cases. In order to avoid this difficulty and at the same time to decrease the work required in computing trajectories in the ordinary way, the following method is suggested:

The connection between range and angle of elevation in a non-resisting medium is given by the expression

$$\sin 2a = \frac{gX}{v^2}, \tag{1}$$

in which X is the range in feet, g the force of gravity, v the initial velocity, and α the angle of departure (*i. e.*, the angle of elevation plus the jump, if there is jump). In a *resisting medium*, v_1, the initial velocity if substituted in this equation would give too small a value of α, and v_2, the final velocity at the range X, would give too large a value; evidently there must be some value, v_m, between the limits v_1 and v_2 which will give the correct value of α. In a resisting medium we might expect good results from a substitution of the mean value of the square of the velocity throughout the trajectory for v in Formula 1. For flat trajectories this mean value will be

$$v_m^2 = \frac{\int_{x_1}^{x_2} v^2\, dx}{x_2 - x_1}. \qquad (2)$$

An examination of Mr. Bashforth's tables of the resistance of the air shows that for high and low velocities the resistance is proportional to the square of the velocity; for velocities between 750 and 1350 f. s., however, the resistance is proportional to higher powers of the velocity, the cubic law of resistance being nearer the truth between these limits than the square. Now, if we call f the resistance of the air in pounds, and R the retardation or loss of velocity per second, we have

$$R = \frac{d^2}{w} f = -\frac{vdv}{dx}.$$

If the resistance of the air is proportional to the square of the velocity,

$$R = -\frac{vdv}{dx} = kv^2$$

$$\therefore \frac{dv}{v} = -kdx,$$

$$\log_e v = -kx,$$

$$e^{-kx} = v.$$

Substituting in (2)

$$v_m^2 = \frac{\int_{x_1}^{x_2} v^2 dx}{x_2 - x_1} = \frac{\frac{1}{k}\int_{v_2}^{v_1} vdv}{\frac{1}{k}(\log_e v_1 - \log_e v_2)},$$

$$\therefore v_m^2 = \frac{1}{2} \cdot \frac{v_1^2 - v_2^2}{\log_e v_1 - \log_e v_2}. \qquad (3)$$

Assuming that the cubic law is true, we have, by similar process,

$$R = -\frac{vdv}{dx} = kv^3,$$

$$\frac{dv}{v^2} = -kdx \;\therefore\; \frac{1}{v} = kx,$$

$$v_m^2 = \frac{\int_{x_1}^{x_2} v^2 dx}{x_2 - x_1} = \frac{\frac{1}{k}\int_{v_2}^{v_1} dv}{\frac{1}{kv_2} - \frac{1}{kv_1}} = \frac{v_1 - v_2}{\frac{1}{v_2} - \frac{1}{v_1}} = v_1 v_2. \qquad (4)$$

Substituting these values of v_m^2 in (1), we have

$$\sin 2a = 2gX \frac{\log_e v_1 - \log_e v_2}{v_1^2 - v_2^2} = \frac{2gX}{0.4343} \cdot \frac{\log_{10} v_1 - \log_{10} v_2}{v_1^2 - v_2^2}, \qquad (5)$$

when $R \propto v^2$, and

$$\sin 2a = \frac{gX}{v_1 v_2}, \qquad (6)$$

when $R \propto v^3$.

In applying these formulas, Equations 5 or 6 are solved for v_2, the final velocity. Having given by experimental firing the initial velocity, and the range for a single angle of departure, one set of firings at a single angle of elevation should suffice for modern heavy guns up to 4000 or 5000 yards range, as will be shown in the examples quoted. Then, by the use of Bashforth's tables, with the values v_1 and v_2 from the formula as arguments, $A\frac{d^2}{w}X$ is found, and thence the constant $A\frac{d^2}{w}$, to be used in the calculations for other ranges. It must be remembered that the errors due to mathematical assumptions not strictly true, to inaccuracy of tables, to assuming that the distance travelled in the trajectory is equal to the range, etc., are all absorbed into the value A. When the angle of departure exceeds five or six degrees, the angles obtained by using a constant determined at a low elevation cannot be relied upon, owing to the greater curvature of the trajectory; but the error may be reduced by firing at a higher angle and getting a new constant.

The following examples will serve to show how the formulas are to be used:

From the Proceedings of the R. A. Institution, Woolwich, May, 1886, p. 356, we take the following data from the range table of the 12-inch B. L. gun, which is based on experimental practice:

$d = 12''$, $w = 714$ lbs. $M.\ V. = v_1$ in the formula, 1892 f. s. jump $+ 6'$, angle of elevation $3°$. Range 3300 yards, using Formula 6.

$$\text{Sin } 2a = \frac{gX}{v_1 v_2}, \text{ in which}$$

$$\left.\begin{array}{l} X = 9900 \text{ ft.} \\ 2a = 6° \ 12' \\ v_1 = 1892 \text{ f. s.} \\ g = 32.2 \end{array}\right\} \text{ and using these values, we find } v_2 = 1560 \text{ f. s.}$$

$$\therefore \frac{d^2}{w} AX = S_{1892} - S_{1560}$$

$$= 1370.5,$$

$$\text{but } X = 9900$$

$$\therefore \frac{d^2}{w} A = \frac{1370.5}{9900},$$

from which we find $A = .6864$.

It is, however, more convenient to use the log of $\frac{d^2}{w} A$ in the computation of other angles for assumed ranges, and in this case log $\frac{d^2}{w}$ $A = 9.14124 - 10$.

We now wish to know the angle of elevation for 1600 yards.

We have $\frac{d^2}{w} A\ 4800 = S_{1892} - S_{v_2}$, and from this formula we find $v_2 = 1725$ f. s. By Formula 6 we have

$$\sin 2a = \frac{32.2 \times 4800}{1892 \times 1725},$$

or

$$2a = 2°\ 43'.$$

Subtract twice the jump, since a is the angle of departure, and we have

$$2 \text{ elevation} = 2°\ 31',$$

or the angle of elevation for 1600 yards $= 1°\ 15'\ 30''$. The range table constructed from experimental firing gives $1°\ 16'$ as the angle of elevation for 1600 yards.

Again, to find the angle of elevation for 4000 yards, we have

$$\frac{d^2}{w} A\ 12{,}000 = S_{1892} - S_{v_2}$$

$$\therefore v_2 = 1495.2.$$

$$\text{Sin } 2a = \frac{32.2 \times 12{,}000}{1892 \times 1725},$$

or

$$2a = 7°\ 51'.$$

Subtract twice the jump, we have 2 elevation $= 7° \; 39'$, or the angle of elevation for 4000 yards $= 3° \; 49' \; 30''$. The range table gives $3° \; 50'$ as the angle of elevation for 4000 yards.

The following tables show the results as obtained by the formulas as compared to those obtained by experiment, and in the case of the 8-inch M. L. R. to results obtained by Bashforth's method.

6-inch steel B. L. R. jump $+ 10'$. *M. V.* 1915 f. s., $d = 6''$, $w = 100$ pounds. Radius of head of projectile, 2 calibres. Experimental results quoted are given in Proceedings Naval Institute No. 37.

1st Case.—Assuming that $R \propto v^3$:

	Elevation.		
Range in Yards.	Experimental.	By Formula.	Difference.
3714	$4°$	$3° \; 53'$	$-7'$
4375	5	4 56	-4
*4990	6	6 00	
5550	7	7 03	$+3$
6057	8	8 04	$+4$

Value of A in this case 0.63767.

2d Case.—Same gun, same data. Assuming that $R \propto v^2$:

	Elevation.		
Range in Yards.	xperimental.	By Formula.	Difference.
3714	$4°$	$3° \; 56'$	$-4'$
4375	5	4 58	-2
*4990	6	6 00	0
5550	7	7 00	0
6057	8	7 58	-2

Value of A in this case 0.70685.

The range marked thus * was used with the corresponding angle of elevation to determine $\frac{d^2}{w} A$.

The 8-inch M. L. R. (converted). *M. V.* $= 1450$, $d = 8$, $w = 180$ pounds.

Assuming $R \propto v^3$:

Range in Yards.	Elevation. Bashforth.	Elevation. By Formula.	Difference.
200	0° 16′	0° 16′	0′
400	0 32	0 33	+1
600	0 50	0 51	+1
800	1 08	1 09	+1
1000	1 28	1 28	0
1200	1 48	1 48	0
1400	2 09	2 09	0
1600	2 31	2 30	−1
1800	2 53	2 53	0
2000	3 16	3 14	−2
2200	3 40	3 37	−3
*2365	4 00	4 00	0
2600	4 30	4 30	0
2800	4 58	4 56	−2
3000	5 26	5 23	−3

Value of A in this case 0.71198.

12-inch B. L. R. (English), column marked *experimental,* taken from Proc. R. A. Inst. May, 1886, p. 356, and based on practice of 24th and 25th February, 1885, 17th April, 1885, and 23d June, 1885. $W = 714$ pounds, jump $+6'$, $M. V. = 1892$ f. s. Form of head not given. Assuming $R \propto v^3$:

Range in Yards.	Elevation. Experimental.	Elevation. By Formula 6.	Difference.
200	0° 04′	0° 03′	−1
400	0 13	0 13	0
600	0 23	0 23	0
800	0 33	0 33	0
1000	0 44	0 43	−1
1200	0 54	0 54	0
1400	1 05	1 04	−1
1600	1 16	1 15	−1
1800	1 27	1 27	0
2000	1 38	1 38	0
2200	1 50	1 50	0
2400	2 02	2 02	0
2600	2 15	2 14	−1
2800	2 28	2 27	−1
3000	2 40	2 38	−2
*3300	3 00	3 00	0
3400	3 07	3 06	−1
3600	3 21	3 21	0
3800	3 36	3 35	−1
4000	3 50	3 49	−1

Value of A in this case 0.6864.

* Used to determine constant.

U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

NOTES ON ELECTRICAL TESTING AND MEASURING APPARATUS FOR SHIPS.

By Ensign S. Dana Greene, U. S. N.

The introduction into a modern man-of-war of elaborate electrical plant has brought into prominence the necessity of having some kind of apparatus on board ship for testing the condition and efficiency of the plant from time to time. When it is remembered that a "plant" now-a-days includes circuits for search lights, incandescent lamps, for guns, torpedoes, gongs, bells, etc., the necessity for having some instrument wherewith to test these various circuits, or to localize faults in them, becomes apparent.

The leading of the wires on board a vessel is, of itself, a laborious undertaking, for so many precautions have to be observed. Thus, wires must be out of the way of an enemy's shot and shell as much as possible, they must be accessible, must be protected from chafe, salt water or undue strains, and the various circuits must be conveniently located for those who are to use them. As a rule, wires are led below the water line wherever possible, double circuits being used above the water line, and whatever apparatus is put on board ship should also be below the water line if possible.

The most ready means of testing circuits, determining whether or not they are in good condition, whether there are breaks, short circuits, etc., is to measure the *resistance* of the circuits, or test their continuity by means of a galvanometer and battery. To enable officers in charge of electrical plant aboard ship to make these tests, there has been devised at the Torpedo Station an apparatus which seems to fulfill the requirements of compactness, simplicity and completeness, and which is called the "Electrical Testing-Table." It

consists of a stout wooden locker containing the voltaic batteries sent to the ship, to the top of which is secured a rectangular table with all the testing apparatus permanently secured to it. To protect the table from dampness, careless handling, etc., it has a cover fitting over it provided with a lock and key. On the table are secured:

1. A *plug switchboard* having binding screws for the attachment of permanent wires to gun and torpedo circuits, a return wire, an earth circuit, and the wires from the batteries in the locker. The switchboard is also permanently connected to wires leading to the measuring apparatus (on another part of the table), and by the insertion of plugs at the proper points in the switchboard any circuit may be connected with the measuring apparatus.

2. A *plug commutator* for connecting the poles of the measuring battery to the measuring apparatus, which is called a *rheometer.*

3. An arrangement for testing the condition of the batteries at any time.

4. The *measuring apparatus* or *rheometer*, with a galvanometer for use with it.

The battery-testing arrangement consists of a resistance coil, an ordinary service fuse bridge, and a contact key, let into slots cut in the top of the table, connected together by wires, in series, and also to the plug switchboard. By manipulating the plugs of the latter, any battery in the locker below can be thrown into circuit with the testing arrangement, and on pressing the contact key (and thus closing the circuit) the fuse bridge should be heated to a bright red color if the battery is in good condition. The fuse bridge is protected from being broken by a piece of glass fitting over the top of the slot.

The rheometer (a plan of which is shown in Fig. 3) is constructed on the principle of the *Wheatstone bridge*, which is as follows:

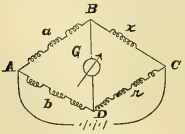


Fig. 1.

Suppose we have a network of conductors, $ABCD$, arranged as in Fig. 1, the arms AB, AD, DC having known adjustable resistances a, b and r in them, and the arm BC a resistance x to be determined. If the resistances a, b and r are so adjusted that there is no deflection shown on the galvanometer G, the points B and D must be at the same *potential* or *pressure;* otherwise there would be a current in the galvanometer circuit, and hence a deflection

on the galvanometer. When the above condition is fulfilled the following relation holds between the resistances in the arms:

$$\frac{a}{b}=\frac{x}{r} \text{ or } x=\frac{a}{b}r.$$

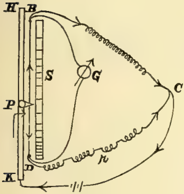


FIG. 2.

Now, suppose that instead of having adjustable resistances in the arms AB and AD (Fig. 1), we have an arrangement like Fig. 2, in which BD is a uniform wire of a certain known length l, HK is a metal bar, having a metal pointer P sliding on it, the latter making a sliding contact with the wire BD. The current now enters by the bar HK, passes to the wire BD by means of the pointer P, and there splits, part going one way and part the other, as shown by the arrows. If now the pointer P is moved along the bar HK until there is no deflection shown by the galvanometer, and if we call the resistance of the wire BD to the *left* of the pointer, a, and that to the right of the pointer, b, we shall have, as we did in Fig. 1,

$$\frac{a}{b}=\frac{x}{r} \text{ or } x=\frac{a}{b}r.$$

Now, suppose that instead of taking the *actual resistance* of the wire BD on each side of P, we call y the resistance per *unit of length* of the wire, and that when the balance is obtained, P is distant v inches from B. Then P is distant $l-v$ inches from D.

Suppose also that $x=nr$. Then

$$\frac{a}{b}=\frac{vy}{(l-v)y}=\frac{x}{r}=\frac{nr}{r}=n \text{ or } \frac{v}{l-v}=n; \text{ hence } v=\frac{n}{n+1}l.$$

To find v for different values of n:

If $x=0.1\ r$, then $v=\frac{.1}{1.1}\ l=\frac{1}{11}\ l$

" $x=0.2\ r$, " $v=\frac{2}{12}\ l=\frac{1}{6}\ l$

" $x=0.3\ r$, " $v=\frac{3}{13}\ l$

" $x=0.5\ r$, " $v=\frac{5}{15}\ l=\frac{1}{3}\ l$

" $x=0.9\ r$, " $v=\frac{9}{19}\ l$

" $x=1.0\ r$, " $v=\frac{1}{2}\ l$

" $x=2.0\ r$, " $v=\frac{2}{3}\ l$

" $x=3.0\ r$, " $v=\frac{3}{4}\ l$

etc., etc., etc.

These values of v can be marked on a scale the ends of which are opposite the ends of the wire BD (Fig. 2), and then when a balance is obtained it is only necessary to observe the reading of the scale S as indicated by the pointer P, multiply it by r, the known resistance, and we have the value of the unknown resistance at once.

The rheometer is constructed on the foregoing principles, and Fig. 3 gives a plan of the rheometer and its connections, the latter being led under the table wherever possible, and let into grooves on the under side of the table.

$QSTV$ is the base board, of hard wood, secured to the testing table. G_1G_2 is a uniform platinum-silver wire stretched between the binding posts G_1 and G_2 and soldered securely to them. NN is a brass bar having the pointer P running upon it, the pointer pressing on the wire G_1G_2 and making metallic contact with it. In the box W are four resistance coils of 1, 10, 100, 1000 ohms resistance respectively, the ends of the coils being connected to adjacent pieces of the switchplug B, as shown. By this arrangement any one, or more than one, of the coils can be thrown into the circuit of the adjustable arm when desired. RM is the scale, graduated as before described, the extremities of the graduation being abreast the ends of the wire G_1G_2. W' is a metal switch pivoted at the binding post b, and which can be switched on to either of the brass stops marked *Tel.* and *Gal.* I is an induction coil; one end of the primary coil is connected to the stop marked *Tel.*, and the other end, through the interrupter J, to the binding post d.

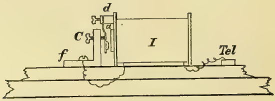


FIG. 4.

This interrupter (see Fig. 4) consists of a brass spring a with a soft iron armature at its extremity, the spring being permanently attached to the binding post d. One wire from the battery goes to this binding post. The spring presses ordinarily against the screw c, which works in the frame f. When a current passes through the primary coil, the coil, acting as an electro-magnet, attracts the soft

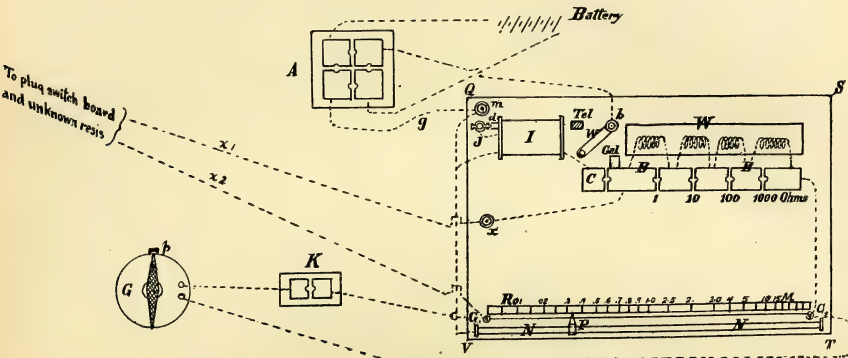

Battery
A
To plug switch board
and unknown resis
x 1
x 2
g
Q
S
m
d
J
I
Tel
b
W
W
Gal
B
B
C
1
10
100
1000 Ohms
x
K
G
p
R
M
N
P
N
V
T

FIG. 3.

iron armature of the spring and draws the latter out of contact with *c*. This breaks the circuit; the coil no longer acts on the iron armature, and the spring flies back against *c*, thus establishing the circuit again. This making and breaking of the circuit results in a rapid, vibratory motion of the spring *a*, the amplitude of the vibration being regulated by working the screw *c* in or out. This vibratory motion is utilized when using the telephone, as described later on.

One end of the secondary coil of the induction coil *I* is connected to the piece *C* of the switchplug *B* (Fig. 3), and the other end, to the wire between the binding post *m* and the rod *NN*. *K* is a switchplug in the circuit of the astatic galvanometer *G*. The latter has two coils, one of 10 and one of 100 ohms resistance, either of which can be used; the galvanometer needle is kept parallel with the plane of the coils ordinarily by means of a small permanent magnet *p*, placed vertically opposite the zero of the galvanometer scale. *A* is a plug commutator connected to the measuring battery and to the rheometer by permanent wires. All the connections of the rheometer are shown by dotted lines in Fig. 3. The commutator is used when it is desired to reverse the direction of the current through the rheometer.

Ordinarily, the apparatus would be used as follows: The pins in the plug switchboard having been arranged so as to connect the proper circuit with the wires x_1, x_2 (Fig. 3), see the pin out at *C* in the switchplug *B*, and put the pin in at *K*, also throwing the switch *W'* on to the stop marked *Gal.*; unplug one of the resistances in *W* (the one that corresponds nearest to the known approximate resistance of the circuit to be measured) and slide the pointer *P* along the wire G_1G_2 until the galvanometer shows no deflection. Then the scale reading shown by the pointer, multiplied by the unplugged resistance *W*, gives the resistance of the circuit or wire measured, *plus* the resistance of the "leads"; the resistance of the latter, being measured before or afterwards, can be deducted from the total resistance. In plugging or unplugging, the pins should never be pushed or pulled sideways; a slight turn of the pin will always seat it well in place, or start it from its seat. If this precaution is not observed, the pinholes become warped or enlarged, and the pins will make bad contact.

Although the needle of the galvanometer is held steady ordinarily by its permanent magnet, there may be occasions when, owing to the motion of the vessel or other causes, the galvanometer cannot be depended upon. To provide for such a contingency, a small tele-

phone, with wires attached, is furnished with the testing table, to be used in connection with the induction coil *I*. To use it, the following changes in the connections must be made: Take out the pin at *K* and put it in at *C*; change the battery wire *g* from the binding post *m* to the binding post *d*, and throw the switch *W'* on to stop marked *Tel.*; unplug one of the resistances *W* as before. Now connect the ends of the telephone wires to the binding posts G_1 and G_2 and put the telephone to the ear. The vibrations of the interrupter spring, when they are properly regulated by the adjusting screw, make themselves known in the telephone by a peculiar humming or buzzing sound. Move the slider *P* along the wire G_1G_2 until the humming ceases, when the balance is obtained. The unplugged resistance, multiplied by the scale reading, as before, will give the *approximate* resistance of the circuit or wire measured. It will usually be found that there are two positions of the pointer *P* in which the humming ceases, depending upon whether the pointer is moved *up* or *down* the wire. The mean of the two scale readings so obtained may be taken as the true reading. For use with the rheometer a battery of four sawdust or other similar cells will be supplied. The current from this battery, however, will not operate the interrupter of the induction coil, and hence when the telephone is used, the firing battery, in the same locker as the other, can be employed. When so used, the circuit should be kept closed as short a time as possible, as the firing battery will soon run down if left on a closed circuit for any length of time. The firing battery should never be used with the galvanometer, as the current is strong enough to fire a fuse, if one should happen to be in the circuit that is being measured or tested; hence it is well to get used to the testing battery whenever the galvanometer is used. With the telephone, only the secondary current goes through the circuit to be measured, and as this is so small, there is no danger of a fuse being fired; hence the firing battery can be safely used to furnish the *primary* current in this case.

While the rheometer is not so accurate or sensitive as the ordinary form of Wheatstone bridge unless the measured resistance approximates quite closely to one of the known resistances, 1, 10, 100, 1000 ohms, it is better adapted for use aboard ship for the following reasons:

1. There are many fewer resistance coils, whose connections are liable to be broken or the coils themselves injured by burning, short-circuiting, or otherwise; hence it is more compact and cheaper.

2. There are not so many pinholes to get out of shape by careless plugging or unplugging.

3. It can stand much rougher handling, and hence is not so liable to be injured by the motion of the vessel, shocks due to firing of guns, etc. This last condition, however, must not convey the idea that the rheometer should be handled or used with any less care then a bridge should be. Any instrument of the kind should be handled intelligently and carefully.

Besides the testing table described above, vessels are now supplied with a small "testing dynamo," weighing only four or five pounds, and very handy, having a bell or gong in its circuit. This bell will ring with a resistance of 5000 ohms in the circuit. In the torpedo-supply box will also be found a "pocket galvanometer," about three inches in diameter only, and which is a combination of a small battery and a galvanometer. It can be used either as a *battery and galvanometer* combined or as a *galvanometer* alone. The testing dynamo and the pocket galvanometer are very useful for testing the continuity of a circuit quickly, testing a fuse or detonator, localizing a break in a circuit, and for many similar purposes. Besides the various instruments already described, officers in charge of the electrical outfit aboard ship will find many articles therein which will serve as material for improvised instruments, either to aid the officer in his routine work or in any special work required, and which will readily suggest themselves to his mind when needed.

U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

OCTOBER 13, 1886.

COMMANDER W. T. SAMPSON, U. S. N., in the Chair.

NAVAL REORGANIZATION.

By CAPTAIN A. P. COOKE, U. S. N.

Ideas are in the air, as Emerson says, and they belong no more to one individual than another. It is impossible to sequestrate an idea for one's exclusive use. The subject of naval reorganization seems now to be in the air, and to occupy naval thought.

The present able head of the Navy Department perceived at once the want of proper organization, and has suggested important changes to meet this great need. The Secretary of the Navy is always a statesman of ability, selected from the people for the control of a great department, but he is not expected to be familiar with the details of naval management, and must rely upon those officers of repute and experience whom he gathers about him as his advisers and as members of his official family. The first necessity is to have this body properly organized, so they may all work together for good and the various branches of the service be efficiently supervised, while, at the same time, the chief control and responsibility may be gathered into one comprehensive head, where it belongs.

The Constitution of the United States declares the President shall be commander-in-chief of the Navy. He is therefore at liberty to perform in person the functions of the Admiral-of-the-Fleet; or he may, at his discretion, appoint an executive commander-in-chief; but he cannot confer upon him his own supreme authority, although he may permit him to carry out his own plans. The question first presents itself as to what are the proper functions of the Secretary of the Navy as regards strictly naval matters and the management of the fleet. Can the President delegate to him the actual command of the Navy or any part of it? Or should he for this purpose assign

an officer of the Navy duly commissioned, or appoint a commission of officers for the purpose of executing the duties of the office of Admiral-of-the-Fleet? This latter course would seem to be the best available.

The commission thus appointed to execute the duties of the office of Admiral-of-the-Fleet would, by their experience, technical education, and general training, be eminently qualified to look after the many details of the service which must be unfamiliar to any one not educated in it.

The unit of organization in the Navy may be considered the single ship, and here the distribution of authority and responsibility is complete; the captain is supreme, and is ably and thoroughly assisted by his staff, with the executive at its head. The chiefs of the various departments look after their respective branches, but running through all is the responsibility of the executive and his assistants, the direct aids of the commander. Next comes a combination of single ships, forming a squadron, under the command of a flag-officer. Here, too, the responsibility and distribution of authority are complete. The captains are held responsible for the units of the formation, and the commander-in-chief looks to them for the efficiency of the single ships. As the executive and the officers of the deck are the immediate aids of the captain in carrying on the affairs of the single ship, so the admiral's staff and the captains of the single ships are immediately responsible to the commander-in-chief for the efficiency and management of the squadron.

Now we have gotten to the end of efficient organization in the American Navy. When we come to the management of squadrons and looking after the general interests of the whole fleet—its outfit ashore, and its efficiency afloat—the weakness of our system is glaringly apparent. We have no proper organization for carrying on efficiently the office of Admiral-of-the-Fleet. This office is located in the Navy Department. Here there are many bureaus, which carefully and faithfully guard the interests of the various branches of the service, but there is no office which effectually looks after the Navy as a whole. What we want is a commission to assist the Secretary of the Navy, and relieve the political head of the department of the many technical details for which he has neither the time nor the aptitude, and which cannot be safely delegated either to clerks or to chiefs of bureaus, who have as much as they can do to attend to their own offices.

Time would fail me to recount the many instances of conflicting authority and cross-purposes which have occurred in the dealings of the various branches of the department with the affairs of the Navy, both ashore and afloat. But they are well known to the members of the Institute, and cause us all to appreciate the radical defects in our organization.

The occupants of the Office of Naval Intelligence should constitute the staff of the commission appointed to execute the office of the Admiral-of-the-Fleet, and would represent an establishment corresponding to the general staff of an army, which is now an essential part of all modern military organizations. This arrangement only gathers up the threads of much that is now left at loose ends, and for which no one is responsible, and cannot in any way interfere with the legitimate field of the technical bureaus. These will continue to be responsible for the fullness of the information and the correctness of the work in their own particular branches, but the management of the Navy will be placed where it belongs, in the Secretary's office; and all orders will be issued from headquarters, and each bureau will no longer have authority to issue general instructions "By order of the Secretary of the Navy," but will attend to its own line of business and confine itself to its own affairs.

In time of war, the department must be suddenly charged with the organization and superintendence of new and arduous naval operations on a large scale, in addition to its current business, and could not, possibly, as now arranged, devote itself to the numerous details, or give the time and attention needful fully to protect the interests of the Government.

The problems of reorganization and reform are too large and intricate to be solved by any individual expression of opinion, but we can all add our mite, and let us hope the fittest ideas may survive and take shape, and be crystallized into some practical form for our mutual benefit. Nor should we be deterred because we appreciate our inability to say much. We can at least construct a thread on which wiser men may hang their beads of wisdom. It may be said the present organization has worked successfully in the past. In the old days, before steam and telegraph, when sails and smooth-bores were our only resource, our organization was sufficient and ample for the times. During our late war, in which we had no prepared naval antagonist to encounter, the duties of Admiral-of-the-Fleet were very ably performed by Captain Fox, a brilliant and talented officer of

great and varied experience, and he felt very much the need of an Intelligence Office, and the store of ready information only there to be found.

Here comes the great advantage of the General Staff, which, I fear, has not been fully appreciated; and we can all remember what opposition the Intelligence Office had to contend with when it was first organized. And now, for a moment's digression, let us reflect how difficult it is to make any changes.

It is astonishing how stubbornly any innovation is resisted, and how blindly we go on failing to observe the signs of the times. When a theory in regard to any important subject has become imbedded in the thought of the time, and when it shapes some important department of public action, so that any change involves the pride of opinion, and would affect varied interests, such a thing will often long maintain its authority after it has been proved false both by reasoning and by experience. The old rulers of thought and practice distrust, or perhaps scorn and ridicule, the new men and their speculations; and Truth, however plain, cannot for a time get herself recognized, and the established opinions and all the related interests struggle hard to maintain their position, and fact and reason are often alike discarded. As a class, we are committed to things as they are, and follow the footsteps of illustrious predecessors, the gallant leaders who have gone before and won renown and honor with the very tools and means which the new men would so ruthlessly sweep away. Prejudice and interest interpose to prevent rational conclusions being consummated.

But to return to the General Staff. Its importance cannot be overestimated, and its services should be utilized to the fullest extent. Its chief labors would be directed to one important end—the preparation for war—so that when the time arrived there might not be a moment's delay. In war the General Staff would be the mainstay and reliance of the department and of the admirals afloat. It would keep itself in close and intimate relations with the outer world, to catch the first intimations of the enemy's movements and to inform the fleet of all his doings and intentions. Members of the General Staff would go with the fleet, and the store of accumulated information in their possession would be kept posted up to the last moment. Previous knowledge and preparation are so essential to success in war, that without a perfected and thoroughly worked-out system of this nature the best ships and equipment will be unavailing. If the

information required is not ready in a concentrated form when war breaks out, it cannot be suddenly obtained, and our operations must be behindhand, and our fleet at a disadvantage continually. The General Staff must necessarily be equipped with the most zealous and efficient officers, and aided by all the available talent of the Navy.

And now let us look again for a moment at the single ship. Her carrying capacity is limited, as well as her resources, and every object, both animate and inanimate, occupying her valuable space should be able to perform as great and varied service as possible. Emergencies acquaint one with strange requirements, and when half the resources at command, and upon which one is accustomed to rely, are suddenly swept away, one must gather up the fragments which remain and make the most of what is left. The quality of these will depend upon the original capacity of the whole. We are aware that at the present day the tendency is to indulge greatly in specialties, and much benefit comes from this division of labor. But on shipboard, where space is limited and all should know how to fight and manage the ship, this tendency must be kept within reasonable bounds by other greater considerations. For instance, the medical profession is divided into many specialties, and some of those would be exceedingly useful on board ship, but, owing to the limited space afforded for quarters, we are obliged to content ourselves with one set of medical officers, who have to combine in themselves all the expertness which can be afforded. So, too, in the matter of torpedoes, electricity, gunnery, and navigation. There is enough in each of these branches to occupy the special attention of different corps, but in the organization of the *personnel* of a man-of-war for effective service it is impossible to have men who devote themselves entirely to these specialties and are fit for nothing else. Suppose, at the beginning of an engagement, half of them should be killed—which is quite likely to be the case—or suppose, during the cruise of a ship, many valuable prizes should be taken, and it became necessary to dispatch these in charge of prize crews: the necessity of having officers of varied accomplishments is apparent. Only a few officers, at best, can be supplied a ship, and it requires very little appreciation of the necessities to realize they should all, as far as possible, be able to take each other's place, and share the responsibilities of fighting and managing the vessel.

The modern fighting ship is dependent upon engines, as the old-fashioned man-of-war was upon sails, and the officers of the latter

with their subordinates were able to care for their vessels in all the exigencies of service, although themselves not expert shipwrights or riggers or sailmakers. So, in the present day, officers of the modern fighting ship must be able to care for all her belongings without the aid of a special class of officers who do nothing but look after the engines and are available for no other service.

In the education of our naval cadets they are taught the same branches, irrespective of the special duties to which their corps selection may call them. And on shipboard, when the vessel is under steam, they have charge of the engines, and when the ship is under sail they are given charge of the deck. They are also exercised in the other important duties of their profession, which fits them to fight and manage a ship and care for her people. This same arrangement of service should be continued when the young gentlemen are promoted to ensigns, and so on through the different grades of watch officers. Then it would be unnecessary to make any further appointments in the engineer corps, and the service would soon become more homogeneous and united. Ultimately an officer might be detailed as chief engineer, just as now he is selected for navigation, and he need not know how to design or build an engine any more than the navigator must know how to design and build his chronometer or compasses, or the officer of the deck must be able to design or build the sails or spars.

The office of the designers and builders is finished when the completed article comes into our hands, and that of the directors and managers begins. A corps of skilled and organized experts must now take charge of the complicated machine. We are told " a man-of-war's-man of to-day is not a mere seaman, but a trained warrior. He is an accomplished artillerist, a skilled rifleman, a trained swordsman, a practical electrician, an experienced machinist, and a superior torpedoist rolled into one." This long list of accomplishments necessary for a modern man-of-war's-man shows how impossible it is to indulge in specialists on board ship.

The engine department of our modern ships will require a large portion of the crew, and this large detail must surely be taught something besides the management of engines. Our engineer officers are required to do nothing now but care for these appendages. In the old times it was found impracticable to have sailors to care for the ship only, and soldiers to do the fighting, so now the sailor-soldier must, as far as possible, be a jack capable of lending a hand at all the

trades represented in our ships; and the officers should be all equally versatile.

Lately the marine officer has been made a sailor by choosing him from the graduates of Annapolis; but it would be better to have him only temporarily detailed for that service. There is no good reason why the paymaster should not be available as a sailor or a soldier, according to the emergency of the moment, and this could be readily accomplished by selecting him from the body of trained naval officers.

In these days of rams and torpedoes, it may be expedient for a ship's company to take to her boats suddenly and unexpectedly, in which case it might be very embarrassing to have a large portion of the people perfectly helpless in the water and unfamiliar with the boats. Every officer should know how to manage and navigate a boat, and should be accustomed to the command of men, and the number of non-combatants should be reduced to a minimum.

As far as possible, every officer ought to serve in every department and branch of the Navy for a reasonable period of time, in order that he may be familiar with other duties than those specifically attached to his ordinary assignment. It is only in this way that he can gain the necessary experience and be sufficiently many-sided to be efficient in emergencies, or capable of performing those many valuable services which he may, in time of need, be required to render.

The introduction of apprentices into our service was a most important step for its improvement, but it has been somewhat halting and incomplete. To make it more effective a larger number should be employed, and the Navy manned as far as possible by those who have been regularly trained for its service, so that all our "blue-jackets" might come from the same source, own the same training, love the same country, and glory in the same traditions. Unfortunately, we find a large proportion of these American boys fail to re-enlist, but I think that proportion can be reduced by judicious management on our part, and when our service is placed on a proper footing. Its defects are as apparent to the men as the officers. They go to sea with reluctance and serve without spirit and without interest, because they find there is nothing in it, and that they are dealing with superannuated and ineffective material which must be swept away and replaced before any good can be accomplished. They find that the service is neglected and unappreciated, and that their best efforts can avail nothing. We need a mighty stirring up.

We are becoming laggards in the race, and the lethargy of routine is settling down upon us. New ships, modern fittings, a new armament, effective equipment, and a better class of men, will do away with this and inject new life into our service.

What we want is a compact body of American seamen kept together by mutual ties and common joys; men of the same household and partners in the same glorious inheritance. It must be expected that a fair proportion of those educated at the training school will not remain in the service, and allowance must be made for this loss—though they are not entirely lost, for in time of war they would be leading recruits and probably the first to present themselves, and their previous training would increase their value immensely. And is not this provision for its defense the legitimate duty of the nation?

We hear of frequent propositions to spend millions in the education of voters, and a modest portion of the public revenue would be most profitably invested in the training of the country's defenders. Only a small portion of the naval officers educated at the public expense are received into the service. We could well afford to educate, in the same way, naval apprentices to be returned to the body of the people and find their occupation in civil pursuits. This would be a most profitable national investment, and in the hour of their country's need they would be the men to leaven the whole lump of patriotic naval volunteers, and be the expert nucleus of our sea contingent, our reliable reserve. And to make this more popular I would have apprentices enlisted from every section of our country. The officers come from all parts of the land, and so should the men; then we would have a purely American Navy, really representing our people. I would train the apprentice as long as I did the cadet, or until he was twenty-one, and then require him to serve a reasonable term of years in order that he might in some small measure compensate the Government for the great honor and distinction bestowed upon him in his selection and careful training for his country's service. None but Americans should be on our ships, whereas a large percentage of our crews are aliens and people of ambiguous nationality, some of them speaking with difficulty our language. Representatives of almost every flag that flies on the sea are to be found at our guns, and the ease with which foreigners may enter our service would make it a very simple matter, in time of war, for the enemy to have informers and spies in our ranks whose presence it would be difficult

to detect. Surely such men cannot be expected to give a good account of themselves in time of war. Nor is this the proper material to put on guard or waste time in training, where every man is expected to do his duty, unless we are to have a peace navy and a war navy, and even then there may be hardly time to gather the peace navy in from the four quarters of the globe under the comforting wings of the great American Eagle, while we set about building and equipping and manning a war navy.

As it will be a long time before we can rely on the training school to supply all our men, we must still have recourse to ordinary enlistments, and there is no reason why the naval service should not be made attractive as a career for young men of good habits and fair education. We have thousands of just such young men, carefully brought up with sufficient education, but devoid of prospects; the tone of the service needs raising, and there seems no reason why we should not introduce a higher order of recruits, and thus make the Navy more representative and popular. We must begin by placing it as much in harmony as possible with the other walks in life which the men we wish to attract may follow.

It may be laid down as a general principle that the greatest attraction will be found to be the shortest possible period of binding service, so that the recruit may feel his liberty has only been pawned, not sold, and that it rests with himself to redeem it almost at will. An employer would obtain but few men if he insisted on a binding agreement for a number of years, with severe penalties for leaving his service, while his men had practically no redress against discharge. Short service would give an opportunity for good men to try the Navy before they elected it as a career.

For the first service of recruits I would permit them to enlist for one year, if they were born in the United States and came up to a fair educational standard, but these men would have to engage for three years on their next enlistment. Some would re-enlist, and the number would be greater as the service improved. Those who failed to return would probably be the first to enlist in case of war, when it might be necessary to increase our force.

Men enter the Navy for various reasons, but chiefly to escape from want or to be free from care, with a future hopeful, if not assured. Many of the idle, the incompetent, and even the criminal, find their way into the service—the waifs and strays left stranded by the active tide of human labor. Out of such material are frequently made the

sailors who have the country's honor in their keeping. But they are not the best we might find in the country, and their character keeps out better men, who would join had they not to live with such associates. Because good men will not enlist, worse are taken, and because of the conduct of these, good men will not stay. This vicious circle spreads and forms other rings. On account of the character of some, the whole Navy must be managed by a system of discipline which would be unnecessary with better material. A remedy must be found if our Navy is to become national and representative of our best qualities. The enlistment of men whose habits or course of life have closed for them other avocations, and who seek the Navy as an asylum of last resort, should not be permitted.

The livery of the United States should be made a badge of character and worth, and the privilege of wearing it considered a great honor, so that young men of spirit and ambition, who are anxious to elevate themselves while serving their country, will be glad to enlist in the Navy. They should be enabled to realize and appreciate the fact that the discipline and instruction acquired during their term of service tend to fit them for the duties of positions of trust and responsibility in civil life when honorably discharged. And the general public would soon learn to recognize an honorable discharge as a certificate of courage, intelligence, subordination, steadfastness of character, and reliability in any pursuit. We should endeavor to elevate the enlisted man, to arouse his self-respect, and thereby enable him to command the respect, admiration and confidence of his fellow-citizens. We must endeavor to attract a higher order of recruits, and thus regenerate the ranks, extirpating all that is low and demoralizing while we instil self-respect and respectability, so that the best men may not dread the association. The day for drunkenness and ruffianism in our service has gone by, and it is high time the last vestiges of it were stamped out. The American man-of-war's-man should be made to feel that by becoming such he does not cease to be a citizen, but retains all the rights and privileges of his citizenship, and is bound to perform all its duties and to meet all its obligations. Such men, on the expiration of their service, would be eagerly sought after to fill many places in civil life which demand the exercise of qualities developed by the training they have received; and in case of war the country would enjoy the benefit of their immediate service. I believe it quite possible to raise native-born enlisted men to a position of dignity and respectability commensurate with their high calling, and to secure thereby an exceptional degree of efficiency.

In a country like ours, where personal success and advancement is supposed to depend entirely upon individual effort and merit, where a free career is offered to talent, and full scope given for vigorous growth, there should be no impassable barrier between the position of the officer and that of the enlisted man. Before 1878 there was practically no promotion for the enlisted man of the Army beyond the position of a non-commissioned officer, all vacancies not filled by the graduates of the Military Academy being generally given to young men in civil life with little or no military experience. The law now requires that all vacancies in the grade of Second Lieutenant shall be filled by appointment from the graduates, so long as any such remain unassigned, and any vacancies thereafter remaining shall be filled by promotion of meritorious non-commissioned officers; accordingly, quite a number have been promoted from the ranks, and nearly all have proved worthy. The selections are carefully made after due probation, the candidate being required to pass two examining boards—one a local board, and the other a general board ordered by the department. Worthy young men often enter the Army in the hope of securing these prizes, and their presence helps to elevate its tone.

I think the legislation for both services should be on parallel lines, as far as practicable, particularly with reference to emoluments and rewards; the number of such promotions must in any case be small, and the varied requirements and strict examinations must make them difficult. Still, they ought to be possible in the naval as well as the military service of a republic like ours. It is certainly an anomaly that a young American seaman is cut off from all hope of receiving a commission in our Navy, whatever may be his services, his talents, or his abilities. If it were possible, it would be exceptional, but that is no reason why it should not be open for men of exceptional capacity and ambition; while such a reward would raise the tone of the men and be of inestimable value in stimulating the zeal of the whole service.

The high qualities of the officers must be carefully guarded and maintained, for as are the officers, so will be the Navy, and the spirit of the former animates the latter. The soul of the Navy is in its officers, and an especial value is rightly placed upon education, because it is the basis of noble qualities. Yet we ought not to cling exclusively to scientific education, but also duly regard qualities of heart and character. It is not absolutely necessary that the men intended for any profession or calling should all be turned out

of exactly the same mould, and Nature's rough school affords abundant facilities for developing the needed brain-power to master the various questions we have to encounter; so it is possible those who have gained their knowledge by experience, and learned to rely on their own resources, may make good officers. At all events, the way should be left open, and the effort will have a beneficial influence. And I venture to think there are those who would not shrink from the labor of preparing themselves for any examination, however difficult. If, in time, no enlisted men can be found worthy of the great honor of being advanced to commissions, it must, in some measure, be the fault of those who have had it in their power to raise the intellectual and moral tone of our men, and have failed to do so. If it is declared that the crews of our war vessels, in whose keeping, at times, is the honor of their country, are thoughtless, drunken, immoral, and totally unfitted to be elevated to commissioned rank, the guilt for this great shame must reside somewhere, and it is high time we set about remedying the evil.

A navy gathered from the slums of our seaports, and from the ranks of the tramps and vagrants, is repugnant to the national pride, and does not inspire confidence in its reliability. There are thousands of respectable and patriotic young men in the country who would make excellent sailors, and who would gladly enlist in the Navy were it not almost considered disreputable to do so. The body of enlisted men of the service should be composed of persons superior in station and education—men sober, moral, diligent, and accustomed to reflect. To such men alone should be committed the honor of our flag.

The measures recommended in what are termed the Schley bills, that were introduced in Congress during the past winter, are most excellent and necessary to establish and assure our "blue-jackets" in their just rights.

The maintenance and treatment of the enlisted man should make him proud of his rank, pleased with his duty, and fond of the service. Above all, he should know and feel assured that in case of being disabled or taken ill he will not be abandoned or cast off, and that those who are dependent upon him will be provided for should he die in the service. This knowledge will give him a confident feeling of security, and make him a faithful, fearless servant.

Short enlistments are more attractive to the men, but long-time service is more advantageous to the Government, and we must accommodate, as far as practicable, these differing interests. Our ships usually

cruise abroad for three years, though they are sometimes kept in commission for a longer period; yet this is exceptional, and should never be the rule. I do not believe in recommissioning ships on foreign stations. It is not economical or conducive to health or efficiency. After a large number of people have been crowded into so small a space for three years, in trying climates, it is time to renovate and renew their abode more thoroughly than can be accomplished while it is occupied; moreover, the ship should be refitted and replenished at home.

When men are first embarked they have frequently been already enlisted from six months to a year. Then great expense is entailed in transporting them home for discharge on the expiration of their enlistment before the end of the cruise. This breaks up the organization of the ship and involves continued changes in the company. Men are enlisted abroad to fill vacancies, which is a great mistake, for they are usually beach-combers, pier-head jumpers, and foreigners speaking with difficulty only a few words of our language, and perhaps never having seen the country under whose banner they have enlisted. When our ships are filled with continuous-service men, all this may be avoided by encouraging the men to re-enlist at once on the expiration of their service, wherever they may be, on the assurance and definite agreement that they shall have three months' leave on their return to the United States.

It frequently happens when men are paid off at home they find it inconvenient to re-enlist within three months after discharge; and that is really a very narrow limit to allow. I would permit the enjoyment of a continuous-service record when a man enlisted within a year after discharge, and allow the three months' gratuity and all the privileges now enjoyed. Great pains should be taken to assist the men in accomplishing their continuous record, and no obstacle not absolutely necessary to secure the Government against loss and to maintain the efficiency of the service should be thrown in the way. It is no small thing for a man to lose all the benefits of such service when nearing the end of his career, and every care should be taken to help him on. One who has struggled successfully through a long term of years to maintain a good record in the Navy, looking to the reward, is deserving of every consideration. The same qualities which have made him successful here would in all probability have made him comparatively independent elsewhere. He must have suffered much and risked much, have passed many years in exile,

and served in climates unfavorable to health and vigor, besides foregoing comforts enjoyed by the humblest class of laborers on shore, and holding always his life a ready sacrifice on his country's altar.

When we have a better class of men we can secure a higher order of petty officers; and in this particular we are weak. We need a class of superior leading men, standing between the crew and the officers, who are reliable, trustworthy, well trained and efficient. Two classes of these men, after careful selection and due probation, should be warranted petty officers by the Navy Department, just as our non-commissioned officers of marines are now appointed. And these appointments should not be taken away from them except by sentence of court-martial. Then these men should be respected, supported and encouraged in the duties of their office. They could relieve the officers of many details and minor services, and would be valuable aids in the training and disciplining of the crew. Our petty officers as a body do not, at present, in any way as they should, fill the place in our organization which the non-commissioned officers occupy in the Marine Corps. And we very much need and feel the want of such a self-respecting body of petty officers.

One of the Schley bills provides for permitting sailors to deposit their savings and receive interest on the same. Something of this kind has been for a long time in operation in the English Navy and in our own Army. It is a very important measure to be introduced in our service, and will have good effects which perhaps are not apparent at first sight. If it were extended so as to provide savings banks for our apprentice school, the influence would be good. These school banks are now very common in many countries, particularly in France, where they are utilized to inculcate a spirit of foresight and economy, and to train the children in practical habits of thrift. Such savings banks are needed in our Navy. Their object is to train men in provident habits. The real end of such banks is the moral training of our naval children, and they have already accomplished great things with children of a younger growth. Thrift is a virtue slowly attained, and cannot be commanded at pleasure.

The evil in which our sailors indulge of squandering their wages in rioting and wantonness is known to us all, and the savings banks would in a great measure deprive them of the facilities for this, and prevent much vice and intemperance, if the spirit of economy were properly inculcated in their early training. On this inculcation of

thrift as a part of the educational training of our young sailors depends in a great measure not only the welfare of the service, but the independence, dignity and happiness of their own future lives.

In our organization the exigencies of war will naturally bring out defects which a time of peace could never discover. It is always easier to point out defects than to define just what remedies are best suited to correct the evils. A free interchange of views and opinions, however, should do much to throw light on these matters, and I do not know of any more appropriate place to discuss the affairs which are of vital importance in our business than the arena which this Institute affords. We must consistently and steadily work out the perfection of our own organization, and our reforms must come from within. Now that a faint, glimmering hope of having a new Navy dawns upon us, this seems a propitious moment for renewed activity on our part, and I hope we shall lose no time in putting ourselves in the position of "the strong man, armed, whose house is at peace." While the multitude of our countrymen are developing the material resources of our rich inheritance, the proud privilege is given us of devising devices for its defense. The people have laid the strong foundations for and are building up a mighty country, while they have selected us to assist in guarding it. And I believe whatever we shall agree together to ask touching the necessities for our service will be willingly granted. But it seems so difficult for us to agree together.

DISCUSSION.

P. A. Engineer W. F. WORTHINGTON.—*Mr. Chairman and Gentlemen*:—I would like to point out some objections to parts of the paper just read. The writer says: "The modern fighting ship is dependent upon engines, as the old-fashioned man-of-war was upon sails, and the officers of the latter, with their subordinates, were able to care for their vessels in all the exigencies of service, although themselves not expert shipwrights or riggers or sailmakers. So in the present day officers of the modern fighting ship must be able to care for all her belongings without aid of a special class of officers who do nothing but look after the engines and are available for no other service." First, there is an inaccuracy in the statement of the case. While it is true that *all* the officers of the ship were not experts, he must admit that among them were the carpenter, an expert shipwright; the boatswain, an expert rigger; and the sailmaker, an expert in his line. Moreover, the analogy does not hold good, because the care of the marine engine, including repairs, is a far more difficult matter than the care of sails and rigging.

Referring to naval cadets, he says: "When the vessel is under steam they have charge of the engines." I presume he means they stand "engine-room" watches under supervision of engineers. If any one present knows of a case in which they have done the duty for any length of time with no engineer on board, I ask to be corrected.

Naval cadets at the Academy make some good drawings and do some good work in the machine shop in this way: The best instruments and tools are put into their hands, they are told how to proceed, and closely watched and instructed during the whole time. Few or none of them become good draughtsmen or machinists, that is, men who could be trusted to do the ordinary work of draughtsmen and machinists without assistance. If such men are given steaming watches at sea, and drills and boat duty in port, how can they increase their skill in either of these branches? When are they to learn to make the necessary drawings, now made by the assistant engineers, for repair work to be done in foreign machine shops? How are they to know if the prices charged are extortionate? to form a correct opinion as to the ability of the contractor to do the work in the time allowed, or to judge if the work has been properly done?

I disagree with the writer when he says: "Ultimately an officer might be detailed as chief engineer, just as now he is selected for navigation, and he need not know how to design or build an engine any more than the navigator must know how to design and build his chronometer or compasses, or the officer of the deck must be able to design or build the sails or spars." Here, as before, the analogies do not present a fair view of the case. One of the principal duties of the chief engineer is to be able to repair any part of the machinery that may break in such a way as to disable the engine. The first difficulty is to remove the broken parts without causing further damage. He

cannot do this without knowing the several methods in which it is customary to put together such pieces, and then judging which method was used in the case in question. He cannot depend entirely upon his set of drawings, for the very detail required may have been omitted, or, as frequently happens, the method of doing the work may have been changed and no note made on the drawings. His next problem is to replace the broken parts by others equivalent to them. He has not the complete outfit of tools and appliances at the command of the engine-builder, and therefore cannot simply produce a copy of those pieces. If he does not know how the pieces were designed, he can form no correct judgment as to which peculiarities of form, material and finish were essential and which not so, and therefore cannot produce pieces that will answer their purposes. But suppose there happen to be on board duplicates provided to supply the places of the very ones broken. The spare parts cannot be put into position without an intimate knowledge of the details of construction of the engine and ability to read intricate drawings, an ability not acquired by many of the present graduates of the Naval Academy, and not likely to be picked up hereafter on shipboard. With the simple machinery now in use at sea, breakdowns often occur which the united skill and knowledge of the chief and his assistants (from four to ten) cannot repair. How much oftener would this happen with the complicated engines of the war ship of the near future, cared for by men who had never seen an engine built and did not know anything of the principles which govern its construction!

The navigator does not need to know how to "design and build" a chronometer, because an ordinary chronometer will run well during the cruise without repairs; several of these instruments are carried to provide for accidents, and there are many more watchmakers than engine-builders in seaport towns. With regard to compasses, several are carried; they do not easily get out of order.

Moreover, the writer says: "The office of designers and builders is finished when the completed article comes into our hands." It would be most desirable if this were the case, but in the present state of marine engineering a complete engine cannot be built to run on indefinitely, like a chronometer. In support of this statement I refer to the frequent accounts of breakdowns given in the daily and technical papers, and to the still more frequent breakages of which we do not read, because it is to the interest of all concerned to say nothing about them. Many of these accidents arise from faults in design, construction and materials, and many more would occur but for the forethought of the experienced engineer, who discovers and provides against the evils of such defects. I have only touched upon the need of a good engineer in time of peace. Further on the writer says we should not have a peace Navy and a war Navy, but the organization should be on a war basis. I agree, and therefore when the machinery of a ship has been damaged in action on a foreign station, is it not worth while to have on board the most ingenious and intelligent and best informed engineer that can be procured, to avoid as far as possible the expense and delay of returning home? Would not a man who understood the business in every detail, embracing design and construction, be more

likely to be able to repair efficiently the machinery than one who had only a superficial knowledge? Were not the ships on our blockading squadrons frequently saved from returning North for repairs by the superior knowledge of one engineer, when another had thought such return necessary?

The writer says we are told "a man-of-war's-man of to-day is not a mere seaman, but a trained warrior. He is an accomplished artillerist, a skilled rifleman, a trained swordsman, a practical electrician, an experienced machinist and a superior torpedoist, rolled into one." We may be told this, but cannot be asked to believe it until we are shown at least one specimen of such an accomplished man. I do not admit that the number of specialists should be reduced, because the combined experience of foreign services has led them to continually increase the number. But if, without any experience of our own to guide us, we decide to reject the results of theirs and to reverse their policy based on it, I do not believe we can ever have less than three classes of officers—the line, the engineers, and the surgeons.

Captain FARQUHAR.—*Mr. Chairman and Gentlemen:*—Naval officers are unanimous in the opinion that some reorganization of the Navy is necessary, but just how this can be done is what we are anxious to know. The author advances some general ideas, all of which have much merit, as might be expected from so distinguished a source.

I think, however, that the plan of a commission to execute the duties of Admiral of the Fleet is, to say the least, very objectionable. As I understand him, this commission is to deal with the fleet—its *personnel*, its organization, its equipment, and its construction. Nothing, in my opinion, would be accomplished by such a commission, because its members would never agree. It would be far better for the Secretary to have as his adviser one officer of ability and rank—one who would be independent of the bureaus. "Too many cooks always spoil the broth." This officer should give all orders by order of the Secretary of the Navy, and be responsible to him alone. He might be the Chief of the General Staff.

The idea of taking officers from the enlisted men is, in the abstract, a good one, but hardly practicable. It would be impossible for them to pass such examinations as are now required for line officers, particularly such an examination as is passed in graduating from the Naval Academy. Besides, we are mustering out every year graduates for whom there are no vacancies. I think this will always be the case, for the supply for our small Navy will continue to be greater than the waste by casualties. I still hold to the argument I made in the Prize Essay of 1885, that the positions of warrant officers—boatswain, gunner, carpenter, and sailmaker—are what the enlisted men should aspire to.

We can never have the best material for the seaman class until we take for apprentices lads who are much better off by coming into the Navy than they were on shore; lads who have no homes; boys from orphan asylums and other similar charitable institutions who want to make their way in the world.

Captain Cooke deserves the thanks of the Institute for keeping the subject of reorganization before the public, and he has my best wishes that success may attend his efforts.

Commander Hoff.—*Mr. Chairman and Gentlemen* :—It is not my intention to discuss the very important and interesting paper we have heard read, but rather to make a few remarks confirmatory of the ideas expressed by the lecturer on the necessity of, 1st, Naval Administration by Naval Experts; 2d, A General Staff. To these two I must add a few words upon a third division, which in the opinion of most of the enlightened European nations forms a preparatory school for the proper performance of the duties of the other two, a Naval War College. We can always count, I fancy, upon a civilian performing the duties of Secretary of the Navy; and although such a condition of affairs would not be tolerated for a moment in any industry which expected to be successful, still our duties, which keep us away in some other part of the world from our fellow-citizens, will probably prevent our being sufficiently well known, or from having sufficient political influence to be put in the ministerial chair of our marine.

Granting, then, that we are to have a civilian Secretary, the argument of the lecturer that we must have a naval head who will be over the bureaus and under the Secretary is not to be controverted. It is the one thing that we in the Navy must put all our efforts into play to procure. This naval head can be one officer, or it can be a committee. I incline to the single man. In a board one man always rules; this is notorious. Although in the multitude of counselors there is wisdom, still where more than one compose the head, the greater is the division of responsibility; and this is something we must avoid. The lecturer's remark that the acts of the chiefs of bureaus should not carry with them the same force as those emanating from the Secretary is most true. It has been this clause in the law which has worked us so much harm. Given originally as a foil to cover the expenditure of money, so as to be within the statute, it has grown to be the sharp sword of several little Secretaries—swords which are generally clashing, to the detriment of the well-being of the Navy.

Not only would the administration be over the *material*, but the *personnel* would be taken care of. The true status of an officer before a board to examine him for promotion would be shown by an officer appointed by the administration to represent the best interests of the Government. Under such a condition of affairs only the worthy would rise. The forcing of the bad or worthless element out of the service could be arranged, so that younger officers could rise more rapidly, and the enlisted man who deserved it could take his place on the warrant officers' list at a very much quicker rate than at present.

As head of the Intelligence Department, the administration would take care that a fairly large expenditure of money was made *in* the Navy, so that officers could gain experience in those questions of the day upon which intelligence had been collated. This work should be carried on at the War College. The War College and the duties of the General Staff are mutually dependable, reflexive. At the War College the duties are such as to prepare officers in the practical portions of their profession, with such little theory as is necessary to an intelligent understanding of the subject, so that, to fill their positions as intelligence officers at sea, their minds are enlarged and quickened

to comprehend what is going on about them in foreign or home naval scientific work. Again, the reports from those officers, formulated at the Intelligence Office, should become the work to be investigated at the College. No administration is possible without a General Staff. No General Staff can exist without a special training.

I am glad to say that this year's work at Newport has been most satisfactory and pleasing to those who have the practical higher education of the naval officer deeply at heart. The motive of this institution may be described as intending to teach practically to the *many* the handling of the weapons of war, and to stimulate the *few* to develop them still further. But this further development must be by some post-graduate course, perhaps best here at *Alma Mater*. But the War College can only point the way to this few: it is not its province to instruct in this regard.

As to the practical results of its work, I may mention something of direct bearing on the General Staff. If we are weak in a naval way, we cannot give up all idea of a naval defense in case of war. So it remains to find out the best we can do. After a lecture on the subject, the Tennessee was ordered to defend herself as best she could against a torpedo attack; the War College to attack with the best means the class could devise and command. The Inspector of Ordnance in charge of the torpedo station was asked to umpire the affair, and to have the officers under him act as judges. After the attack, each party wrote its account of what happened, and what would in its opinion be the best defense of, and an attack upon, the Tennessee with the means at hand in our Navy. These reports probably, with the criticism on the attack and defense by the judges, form the very best thing that can be done by our Navy on this question, and fill the first pigeon-hole in the General Staff Office. Next summer, with improved material, this information may be very much modified, but the last information will always be on file.

We may not obtain such an administration for some time as our lecturer has sketched out for us, but I am certain that it is the thing to work for; for no success is possible without such an office. Our shores might be lined with our men-of-war, but still we would have no Navy. We officers, who consider ourselves the peers of any who tread the quarter-deck, are, after all, only instructed as a general thing, in one antiquated third of the science of warlike offense—the use of smooth-bore guns. Even this instruction, a branch of naval tactical science, has been heretofore taught by an ordnance organization. Ordnance has only the same relation to gunnery that naval construction has to seamanship.

Without statute can a naval administration be erected in the Navy Department? Our lecturer says that it can, and shows the way.

Let me tell you a little bit of history, perhaps not known; but it reads like a romance. The war of 1812 came upon us with the Navy, as at present, the football of the nation. Still its record was most honorable; its officers were men the mention of whose names still stirs our blood. They are dead now; here are their winding-sheets about us. A timid President, a civilian Secretary of the Navy, had determined, as, perhaps, the President and the Secretary of

the Navy in our next affair will determine, that the ships should all be laid up, their crews drafted into the army, and that they and their officers should garrison the seacoast forts. Stewart, Bainbridge, and I think Hull, it might have been some other captain, were in Philadelphia. They immediately started to Washington to see what they could do to prevent this cowardly piece of work —this traitorous, dastardly action on the part of the Government. On the way down, so the letter from which this history is drawn says, they determined that they would petition the Secretary to rescind the orders dismantling the ships. If this failed, they would petition the President; if this latter failed, they would, as a committee, storm the halls of Congress! What matter to them if they were besieging the Government without form of law? Their profession had been learned under Preble in engagements with Algerian corsairs; they had languished in Tripolitan prisons. Men they were who loved the sea, and the sea knew them. Now their birthright was to be stolen from them. They, a board of self-constituted naval administrators, would fight against the unlicensed encroachment of their craven superiors.

It was July, and the three men arrived at night. The next morning they called upon the Secretary before he was up. He said that he would see them at the Department. They saw him, but with unfulfilled wishes; in time they turned away. There was nothing to be gotten from him. They had permission to see the President. They called at the executive mansion; the President was absent; he would not be back until Monday, and it was now only Saturday afternoon. They went back to their scorching lodgings, and so far were these men from being disheartened that they decided not only must their petition be granted, but that they must have a complete scheme for a naval policy to offer the President. From that afternoon until Monday morning they wrote; the pen was never idle. Bainbridge said two lay out the window while the third wrote. Here, in a country town, although a capital, in a scorching room, was the first General Staff duty in the United States Navy accomplished. Without sleep, Monday morning saw the men at the White House. The President was seen, the petition read. The President asks the question, What could possibly be done with the ships, should his orders be rescinded? His answer was in the paper which was handed him, and which saved the Navy to our country. Their point was well made.

So, in the sweat and vigil of the pitiless heat of summer nights and days, did these determined men write the first page of the most glorious chapter in the history of our country. Do the spirits of these mighty men still live in us? If it is so, let us be up and doing!

Captain YATES.—*Mr. Chairman and Gentlemen:*—The paper of Captain Cooke suggests many ideas to me that I have entertained before. I agree fully with what he says regarding the necessity of a commission to assist the Secretary in the technical details of the service; in fact, so firmly am I convinced of the necessity of such a course, that I am doubtful of any permanent improvement in the condition of the service until a board or commission is instituted by law with authority to act in the details of the service, and to be

held responsible for the counsel it gives to the Secretary, and, so far as this is followed, to be held responsible for the condition of the whole.

Neither time nor space will permit me to give my reasons for this course; nor can I do more, for the same cause, than say I think it impracticable to make one person capable of being shifted from the position of Executive, Navigator, or Watch Officer to that of Chief Engineer. In other words, to obtain excellence in either profession one must devote too much time to one exclusively to become expert in both. For this reason it is my opinion that after the first two or three years at the Naval Academy, cadets should be permitted to select their corps and be educated accordingly; all to be given the necessary knowledge of all branches to be of the greatest use in battle or times of emergency.

In all that Captain Cooke says regarding the apprentice system and the necessity of having trained and respectable seamen to man our vessels, I fully agree. It is to be borne in mind that not only would these apprentices come to the country's aid in time of war as seamen, but should the increase of ships, gunboats, etc., for any reason be so great as to render necessary the appointment of junior officers from civil life, what class would be so competent to pass the required examination, or be more efficient, than these same apprentices, who were discharged at the age of 21 years, or after a longer period of service?

It is true that an impassable barrier exists to the promotion of the enlisted man to a commissioned officer. This, in times of peace, cannot be otherwise, when the knowledge and training necessary to make a naval officer are considered. The Naval Academy is open to boys in all the walks of life, and there is no privileged class in this respect; and the officers come as distinctly from the people as if promoted from enlisted men. The barrier might be opened in time of war to those who have served a certain number of years as apprentices, are capable of passing a determined examination, and have the recommendation of the commanding officers with whom they have served. If this privilege were made public, it would be something of an allurement to retain the apprentices in the service, and do much to satisfy the ideas of justice of many of our very democratic countrymen.

As additional inducements for apprentices to remain in the service, I recommend the raising of the seaman class to a level with that of the special and artificer classes in the matter of pay. Without dwelling more upon this subject, as I have specially called attention to it in remarks at the meeting of the Newport branch of the Institute last spring, I would ask officers to examine the pay-table of the Navy, particularly the pay of the seaman class ranking with machinists, yeomen, etc. There are no more of the former on any vessel than of the latter, and not as many. The increase of pay recommended would be but slight, and the seaman apprentice would not think that, in the estimation of the country, aside from all sentiment, the seaman class is deemed the least valuable of any in the Navy.

Offenses and punishments should be classified, as far as practicable, and then published, and the greatest amount of liberty on shore consistent with discipline and efficiency should be given. In the new vessels improvements in the men's quarters have been made; still it appears to me there is room for more.

Petty officers should be rated and disrated by the action of a board of three officers, subject to the approval of the commanding officer. The outfit of clothing should be paid for by monthly instalments of about one-sixth or one-fourth of the pay of the recruit, and during the period of such payments he should be considered as out of debt, so far as monthly money and liberty are concerned. The mattress and blankets should be given to the recruit gratuitously. Savings banks should be instituted on board the ships, as recommended by Captain Cooke, and by Captain Farquhar in his prize essay of last year. The warrant officers, except the carpenters, should be selected from the apprentices. This should be made obligatory by law.

The pension laws should be so amended that seamen or persons in the naval service who enlisted as apprentices and served their term of apprenticeship shall, after 21 years of honorable service after attaining their majority, be allowed to retire from the service, in times of peace, with a pension equal to 50 per cent. of the pay of the rating held at the time of their discharge; those who have earned good-conduct badges should receive, in addition to the 50 per cent. of their pay mentioned, 5 per cent. of the same pay for each badge so received up to this period of their service. In accordance with the Department's General Order No. 327, the pension of a man who should receive a good-conduct badge at the expiration of each of his terms of enlistment would be 80 per cent. of his pay in active service.

The continuous-service certificate and the good-conduct badge regulations work admirably, and I have had some experience in knowing how highly the former are held by their possessors, since I have been in command of the New Hampshire, in my endeavors to obtain good instructors for the apprentices. As this vessel is included in the Bureau's order relative to the employment of continuous-service certificate or general-service men on stationary ships, men who possess the continued-service certificate would rather go to sea than lose them and their privileges, although some leave their families on shore and give up on this ship some of the highest rates in the service.

In my opinion, the whole service should be open to the selection of instructors, petty officers and seamen for the training squadron, including the New Hampshire; for in the training squadron the first impressions and lessons, so long remembered, are given.

The system, as at present established, is, in my opinion, the best. The conditions of society in our country are such that the boys should not be taken younger than 14 years. They should not remain on the stationary ship longer than the six months now set. This is long enough to teach them how to live on board ship, and give them a good start in their drills. Desertions are more frequent than desired, though the majority of those who have gone lately are, I am pleased to say, the worthless ones. I believe if the law would permit the discharge of a boy when a board reports he has no aptitude for the service, from whatever cause, even to positive dissatisfaction, without regard to the state of his accounts, and would try by a general court-martial a few deserters, the effect would be very beneficial. Keeping them in the service until they are twenty-one, or are out of debt, is a great expense to the Government, and their

influence upon the other boys is extremely pernicious. In the New Hampshire the greater part of the weeding out should be done, and from my experience two or three months are sufficient to enable one to judge of a boy's capabilities.

From my experience with the apprentices thus far, I must say that I am more than pleased. Their boy nature is no different from that found in the best boarding-schools in the country, and if it is surrounded by proper influences, and the consideration shown to youth and youthful pranks that a healthy discipline will allow, the apprentices can be moulded into a body of the best seamen in the world, in whom the country will have a just pride and the service find the greatest aid to efficiency.

Lieutenant-Commander Stockton.—*Mr. Chairman and Gentlemen:*—The interesting and suggestive paper by Captain Cooke brings to the front in a direct manner for discussion various subjects, some of which of late have been the cause of wide and frequent discussion in public and private; while others, though doubtless at times the subject of conversation, have not been presented before in this public manner to the members of the Institute and the officers of the service.

The constant interest in all matters likely to advance the service which impels the writer of the essay to publish his views should be appreciated by all, whether called upon to agree with or dissent from his various propositions. Remarks upon a paper like this must necessarily be critical, and suggestive only to a limited degree. Those now offered by me are intended to touch very briefly upon a few of the subjects treated, and not as a comprehensive review of the paper. Fuller treatment would be offered only when demanded by the proper circumstances,

The author of the paper has referred concisely to some of the defects of the present organization of the naval service and the Department, particularly in that the Navy, after a logical, systematic, and military organization afloat, finds in the central administration and Navy Department no professional, naval head and commander-in-chief. The Lieutenant-General of the Army, commanding the Army of the United States, with the President and Secretary of War as his immediate superiors, has no counterpart in the Navy; and often the Secretary of the Navy is forced to have a substitute, who, without the rank, responsibility, or emoluments, becomes, for the time, the actual, though not the nominal, commander-in-chief of the naval service. This has been the condition of affairs for many years.

The essayist proposes to put this place in commission—to have a board or commission to execute the office of Commander-in-Chief. It seems strange, after the many failures of the past, and the lessons of political administrative and military history, to propose again to invest a board with executive authority and duties. Take the early history of our own country; that rope of sand, the Articles of Confederation, had as an executive authority a body of men, while the framers of our Constitution wisely vested in one person, the President, the execution of the laws and the administration of the policy of the nation.

The French have a single head, in a naval sense, in the Minister of Marine, who is an Admiral of the Navy, professionally competent; and, in the cumbersome English Admiralty, the various members of the board in its workings are subdivided into heads of naval and civil departments.

Fully aware of the many schemes and plans to rectify this obvious defect, I venture briefly to suggest one more, which seems to me both natural and logical. Let the naval head of the service be the actual professional head. Perpetuate the grades of admiral and vice-admiral; require by law the retirement of these officers either at sixty-two or sixty-four. Promote to these grades, as well as to rear-admirals, by selection; no one to be selected unless as rear-admiral he has commanded a squadron at sea, and has at least two years to serve in the grade; and then make the Admiral of the Navy the chief of the *personnel* and the head of the naval service in the Navy Department. Let the official and actual head be combined in the one person. The Army has this system of promotion, and has been the better for it; it is a necessity in war, and good administration in time of peace.

The Secretary of the Navy, with the proposed Bureau of Construction, Material, and Repair and the Bureau of Supplies and Accounts under his direct control, both to a great extent civil in their nature, would find his energy and time fully occupied.

The Admiral of the Navy, chief of staff to the Secretary, in immediate command of the fleet, would have in charge the *personnel* and all matters directly connected therewith; in other words, under and by direction of the Secretary he would have charge of the recruiting and training of officers and men, the inspections and drills, the detail, the discipline, and, finally, the movements of vessels and squadrons. In all matters concerning the *personnel*, he should be superior to the chiefs of bureaus. The Vice-Admiral could be placed in naval command of the Pacific Coast of the United States, including the Navy Yard at Mare Island, and some attention might in this way be officially called to the almost entire want of military and naval defenses of that coast, especially the Northwestern frontier and its great waters.

Great stress is laid upon the importance of a General Staff; its utility is not overrated, but, after all, it is only an adjunct, and should be for the use of the Admiral, the service, the Secretary, and, if need be, the President of the United States.

The essayist does well to call attention to the necessity of the reduction of the non-combatant element on board ship; it should be restricted, both among officers, petty officers, and men, to the smallest practicable number. Whatever number of specialists and experts may be needed on shore for the designing of ships, ordnance, machinery, and electric plant, the officers on board ship should be familiarized only with the *use* of the material furnished, and should not attempt to become competent manufacturers and expert designers of the same. The number of persons needed to design and superintend the construction of material for the Navy will be extremely small, and they should be relieved in some way from the active duties of the service. It will not do to attempt to make expert designers of all of the members of the various corps and grades of seagoing branches of our profession.

As the paper advocates, the apprentice system should be extended, and it should be the principal, if not the only, means of supplying enlisted men to the service; but the urgent necessity of affording sufficient inducement and attractions to retain the men thus trained must not be overlooked. These inducements the service does not at present offer. There is so little present or prospective stimulus offered for progress in efficiency that the retention of the best men and their choice of a career in the service cannot be counted upon. No graded increase of pay is offered as a reward for increased activity and more extended training. One can hardly glance down the three *parallel* rows of the pay-table of the petty officers, etc., contained in the Navy Register with any degree of patience. Take the pay alone of chief boatswain's mate, who is the leading blue-jacket on board ship, and who takes the place of boatswain in the smaller vessels of the service. His pay of $35 a month is the incentive an apprentice has as a reward for the attainment of that position. There are nineteen petty officers of the artificer and special classes who receive more pay than this most important combatant petty officer. A more glaring defect does not exist to my knowledge in the service.

Every opportunity should be taken to urge upon Congress the passage of what the essayist terms the Schley Bills. When passed they would mark a long step in advance for our men, and if accompanied with the rectification of the pay of the petty officers and trained men, which does not require legislation, a new era would be opened for the enlisted men of the service, to induce them to serve more faithfully, more permanently, and more honorably under that flag which owes so much to the exertions of their predecessors.

Commander SCHLEY.—*Mr. Chairman and Gentlemen:*—In most discussions touching naval reorganization, it appears to me that many officers confuse its organization with its administration. The paper under review recommends a commission to assist the Secretary in matters of its *technique*, but the intended scope of its authority is not defined, except to relieve the Secretary of many technical details of his office. As all of the technical details of the Department are now, by general order, performed by the bureaus, the suggestion would add more machinery to the Department without simplifying in any respect its business working.

The paper then proceeds to state that the "author's time would fail him to recount the many instances of conflicting authority and cross-purposes which have occurred in the dealings of the various branches of the Department ashore and afloat"; and, therefore, the organization of the Department is condemned. What he condemns is administrative, and could result under any organization that lacked proper administrative discipline. There is no law defining departmental administration, and I am quite free to say that there ought to be none. The Secretary, if a good business man, will always attend to this part of it. The methods of the Department business should be left entirely to the Secretary, as at present, that he may introduce any system he may elect. If, after trial, one plan fails, it would be unfair to force him into Congress for its repeal before another could be tried. To my view there is something eminently proper

in leaving the Secretary independent in these things. As he is responsible to the President for the administration of his Department, he ought to be free to control its business, to conform it to the method of successful private corporations. There can be no doubt that the Secretary has struck upon the chief defects of the Department in his reformation of its business administration. When he shall have completed these, as contemplated at the present time, and extended them into the service afloat, there will be less cause for complaint than now.

There is nothing in the law to prevent the Secretary from calling to his aid an officer whose duties would be to advise him in all matters relating to the movements of the fleets; and I do not doubt, if he felt its need, that he would do so. But as he is likely at all times to have around him in the Department officers of some merit in their profession, I cannot well see the importance of adding one other, whose entire duty would be to perform the only remaining duties which the paper leaves for the Secretary. It is difficult to account for the constantly expressed desire for change of naval organization, so common in our profession, upon any other theory than that, our professional lives being made up of constant changes of station, we are thus really educated to restlessness. Since the establishment of the Navy Department, somewhere about the year 1800, there have been no less than three different organizations in it; all in turn have been overthrown, and now this paper advocates still another, which it styles a commission—really, I assume, a sort of Admiralty Board. It might be well for most of us to read a recent book on the English organization entitled "The British Navy in the Present Year of Grace, by an Undistinguished Naval Officer," and the reply to it by a "Lieutenant, R. N." The former is unquestionably overdrawn and somewhat spiteful; but when supplemented by the information of the reply, there can be no question that we should gain nothing in making a change in our organization to assimilate the British. If their system of organization is susceptible of the complaint and mismanagement charged, it might be well to look well before we leap into anything like it. But in view of the suggestions of this paper, and those of the two books cited, it would be interesting to know which of the two is right, if my assumption is correct that a commission really means a Board of Admiralty.

Every Commander-in-Chief abroad has his General Staff, and I quite agree with the paper that it might be well to require each member to gather up every scrap of information coming within his reach relating to the latest advances made by foreign nations in all things affecting their offensive and defensive preparations. These reports should all find their way to our "Intelligence Bureau," to be published, as now, for our information and guidance.

I quite agree with the author of this paper that all officers of the Navy, except surgeons, whose duties are distinct, ought to be educated for command. It is certain to happen in future naval combats that the destruction of life will be immeasurably greater than ever before by reason of the multitude of rapid-firing and machine guns now composing the armament of modern war vessels. If this be true, then we need a larger reserve to fall back upon than was necessary when we possessed fewer means to destroy life than now. In this view

the education at the Naval Academy is most proper, and from that institution should come all the officers in future. Such titles as engineer, marine, and pay officers should disappear in their temporary assignment to these duties for the cruise. Surely good organizations would require this concentration of the official *personnel* of the service, that no excuse could exist for defeat that might come to us now from the destruction of all combatant officers, while a large percentage of the non-combatant class were left untouched, but untrained to manœuvre or fight the vessel.

It must be admitted that with the disappearance of sail, or with its use in a subsidiary sense only in our war vessels, the education of officers and the training of men must differ from the practice of former days. The new and higher seamanship as applied to steam vessels of great power means the most intimate acquaintance with their tactical power, their various contrivances for gun control, their torpedo outfit for attack and defense, their interior arrangement and construction, their electric attachments for comfort or for use in attack or defense ; all these things are to be acquired, in addition to the indispensable knowledge of taking care of the vessel at sea.

Turning now to the enlisted men of the service, there can be no doubt that too much importance cannot be given to the selection of Americans for service on board our national vessels. But if it is remembered what the possibilities buttoned up in every American boy's jacket are, it will be apparent that we must provide for their future in no indefinite way. In other words, if we expect American boys to make their homes in the Navy, their living conditions are all to be improved, as you improve them in mental fitness for the newer duties. When worn out or injured in the service, they must be cared for in no uncertain manner.

When vacancies happen in the grades of boatswain, gunner, and sailmaker, those American boys best fitted should be promoted to fill them. And when they have reached a certain length of service in the ranks, they should be retired in the same way that officers are retired, with 75 per centum of the pay of grade they reach on retirement. Savings banks should be established for their benefit, to invite and cultivate habits of thrift in money matters. When filling the position of petty officers their tenure should be for the cruise, and their reduction should not occur without a court-martial. It should never depend on the caprice of commanding officers.

The articles of war should be modified, so that much which is copied from the old English system, applicable to a period of time away back in the past, should be expunged as belonging rather to the days of the rack and torture. As you educate and train men, less punishment is needed in governing them, and their own self-respect is your best assistance. It seems to me that if we teach men to respect themselves, they will be better prepared to respect their officers and the lawful authority under which they serve.

This appears to me the direction our reorganization should take. In this we are all supposed to be experts, and I am convinced if we shall turn our attention to this important practical question and give our best efforts to the solution of these matters in the interest of our American sailors, all the diffi-

culties complained of in this paper will disappear as mist before the sunshine. I see no other solution of this problem, though we may theorize upon it until the end of time.

Commander HARRINGTON.—*Mr. Chairman and Gentlemen*:—I am unwilling to pass without dissent the views which have been expressed by one of the officers present with regard to the office and employment of the naval engineer.

The care of the engines and boilers of a war vessel is purely mechanical duty. At sea, the lubrication of the machinery; the prevention of heating in bearings; the regulation of the supply of water to boilers; the firing; the stopping, starting, and reversing of the engines at the signal from the officer of the deck, and all the other usual duties of the officer in charge of the engine room, are practical matters in which unlettered men become expert. In port, the examination of engines, fitting brasses, cleaning boilers, and all repairs to machinery are solely the work of machinists, boilermakers, coppersmiths, blacksmiths, and other artisans, whose handicraft has been acquired in manufacturing shops and on board ship. During the Civil War the management of the engines of our vessels was very largely in the hands of men, brought from machine shops or from the merchant marine, who had little knowledge of books and scientific steam engineering. They understood the working of boilers and engines; they could handle tools and repair machinery; and they did their work well; but they were not men of scientific attainments nor even of liberal education. The younger line officers of the Navy, graduates of the Naval Academy, have been appointed, under the orders of the Navy Department, to perform duties in charge of the engines of our war vessels while under steam. Many of us can testify to their rapid acquisition of knowledge and their ultimate capability and efficiency when in charge of the engine and fire rooms. The engineers of the great steamers, which cross the ocean at high speed and without stopping during a voyage, are not scientific men. The majority of them spring from the shops of shipyards and continue to discharge during life the laborious duty of running a ship's engines. When accidents to machinery occur on board ship, the senior naval engineer directs what repairs shall be made, but he does not make them, for that is the machinist's work. Indeed, the engineers of the Navy at sea are now chiefly engaged in superintending the performance of the machinery. A few of them stand watch in the engine room, but the greater part of this duty is done by machinists and by young line officers.

The more highly educated the professional engineer, the more averse he will be to the routine duties of the engine room; and with reason, for it seems irrational to educate a man in all the higher branches of the science of steam engineering and then put him to do a life-work of running engines, in which work his scientific acquirements will prove of little use. Some experience in the engine room, in working engines and boilers, is necessary to the complete education of a steam engineer; but, if running engines is to be his chief duty in the Navy, a scientific education is unnecessary; if he is to be employed in higher duties, in the superintendence of machinery afloat and of the manufacture and design of machinery on shore, he must be relieved from the ordinary

watch duties and the daily work of machinists on board our ships. High professional research and daily mechanical employment are not compatible, except in rare instances. We do not find, often, science and mechanical skill combined in one man.

I conceive that the engineers of the Navy should be employed chiefly to superintend the machinery of cruisers. Some may be stationed on shore to inspect the construction of machinery. A few, and only a few in our small Navy, will be required to engage in designing and construction. The great majority of the corps should find their work in charge of the engineer's department of war vessels; and for this duty their professional education should be extended. They must have experience in the workshops and in the management of engines and boilers. They should be practical men, accustomed to consider all difficulties with machinery and to suggest ready remedies, and competent to direct the efforts of the engineer's force so that the engines may develop the best results with certainty. They should be able to judge, from a scientific point, the performance of machinery and to project improvements upon it. They should be experts in machinery of all kinds and competent to prepare reports upon new engines which they may view abroad.

One or two professional engineers on board each large ship should be sufficient. To run and repair the engines of our ships we require a body of machinists, under the orders of the superintending engineer of each vessel. These machinists should be schooled in the machine shops and in working engines and be expert in the use of tools. They should do the work which is unsuited to the rank and acquirements of scientific engineers and which professional engineers do not perform. Proper grades for promotion, permanence of appointment, and longevity pay, will secure reliable and capable men for this service.

I do not agree with the essayist that the employment of line officers in the engine room should be continued to such an extent that they may be ultimately detailed for duty as chief engineers. The line officer's occasional employment in the engine room is useful in its results; but I consider that we shall not draw for each ship from the body of line officers, whose minds must be largely directed to other vital acquirements, officers of the special knowledge desired in the superintendent engineer I have described.

The non-combatant element in our ships should be reduced, eliminated if possible. By non-combatant element I mean that large class of men on board our ships who do not take part directly, and are not trained to take part, in working the great guns and other weapons. At general muster the long line of non-combatants is appalling. Our crews should be homogeneous in nationality, in class, in capability, and in training. The able seaman will be in the future, as in the past, our force, our trusty agent, and every other type of men on board should be assimilated to him. The engineer's force should be trained at the great guns, at the secondary batteries, with small arms, and in the boats. Few servants should be enlisted; indeed, they might be taken from the sailor class. Abolish paymasters' clerks and naval cadets at sea, and put the remaining steerage officers into the wardroom. In conflicts be-

tween ships, ramming is most probable; ships will come together; and, for such an event, every man in a ship should be trained, each with a proper weapon, to keep his own deck or to go on board the enemy.

The argument of homogeneousness extends to the marines and would exclude them from a vessel of war. It does not seem wise to have a special class of men for one arm, men who do not work in all the duties of the crew. The marines are now employed on board chiefly as sharpshooters and as sentinels over Government property and refractory sailors. But the seamen of our Navy must become sharpshooters, and they must learn to guard themselves and their ships. A proportionately large part of the crew must be employed in the engine room; outside of it there should be but one class of men, the able seamen, who should be entrusted with every duty and office of the ship under the commissioned officers.

I have outlined an opinion, in which many officers concur, based upon the principle that no man should be retained on board who is unable to perform one, and, usually, more than one, of the essential duties of the vessel of war. The elementary training should be done in separate ships. There is no place in a ship prepared for war for naval cadets and clerks, who take up the room of officers; nor for boys and servants, who exclude as many fighting men ready for any work with any weapon in any part of the ship; nor for yeomen, writers, schoolmasters, ships' corporals, lamplighters, tailors, barbers, buglers, printers, painters, etc., unless they are seamen or form a part of the fighting force.

These suggestions of the employment of machinists and of homogeneous crews spring naturally from the practice existing in foreign navies.

With regard to the employment of engineer officers, we find that Great Britain has a greater number, proportionately, than any other country. The number of engineers appointed to the vessels of the British Navy serving at sea in April of the present year runs as follows—viz.: In each of twenty-nine ironclads and large vessels, whose displacements range from 10,820 to 3080 tons, and of 8600 to 3500 horse-power, one chief engineer and three assistants form the regular allowance; supernumerary assistant engineers are appointed to a few of these vessels for detail to other ships or for special service, so that we find one ship with eight engineers, one with seven, seven having six engineers each, seven having five, and thirteen with four only; for twenty-four other vessels, whose displacements range from 9330 to 1760 tons, and horse-power from 6750 to 1830, the allowance is one chief engineer and two assistants; in each of six other vessels, whose displacements range from 3560 to 2120 tons, and horse-power from 2190 to 1145, there are one chief engineer and one assistant; and one engineer is assigned to each of sixty other vessels, of which twenty-three are from 900 to 1500 tons in displacement and 900 to 1400 horse-power, the remainder being of less than 900 tons. It appears, however, to be the policy of the British Admiralty to reduce the number of engineers serving at sea. The total number of engineers decreased from 974 in 1872 to 777 in 1880, and in the latter year about five-sevenths were serving at sea. The total number has been further decreased to 687 in the present year. On

the other hand, the number of engine-room artificers increased from 176 in 1872 to 612 in 1880. Writing in 1882, Sir Thomas Brassey said: "Since the introduction of artificers into the (naval) service their number has been steadily increasing, while the engineers have been proportionately reduced. There seems reason to believe that the movement might be carried considerably further. * * * * The mechanical branch requires a certain number of superior officers. They should be formed into a staff corps, in some respects answering to the French *génie maritime*. A staff officer of naval engineers should be attached, as in the French Navy, to every flagship, and one or two should be appointed to each first-class ironclad. In the subordinate ranks skilled mechanics would be more useful."

In the French Navy, the marine engineers (*génie maritime*), ninety-three in number in 1884, do not serve at sea. They form a corps of constructing engineers, drawn from the graduates of the Polytechnic School at Paris, who also graduate from the Cherbourg School of Application for Engineers, and their duties are wholly in designing ships and engines and in superintending their construction and repair in the dockyards and at private works. Another corps, called machinists (*mécaniciens-en-chef et mécaniciens principaux*), furnishes a small number for the largest cruising vessels of the navy. The machinists numbered ninety-six in 1884, of which forty-five were afloat. These are commissioned officers, though they do not bear the name "engineer," nor do any of them attain higher rank than that of lieutenant-commander. Most of them rank with ensigns. They are the superintending engineers of the ships in which they serve abroad. The men who have charge of the engines in nearly all vessels of the French Navy bear the title machinists (*mécaniciens*) and have the rank of warrant officers. They have been trained in the management of boilers and engines at the School of Machinists in Toulon. Their education in practical steam engineering is very thorough; in mathematics, mechanics, and physics their instruction is elementary and has special reference to steam engineering. These machinists become eligible, upon passing certain examinations, for the lowest grade of commissioned-officer machinists.

In the German Navy there is a small corps of mechanical engineers, who are charged with the care of engines on board the larger ships. The members of this corps are graduates of the school at Kiel. The engine-room watch duty is done by machinists, who are eligible for the school at Kiel. The engineer corps of this navy is a separate body, and its members do not serve afloat. The corps numbers sixty, about half of whom are engaged in constructing ships and the remainder in building engines.

Italy has adopted the French plan of education. She has a corps of constructing engineers, who do not serve at sea, numbering in 1883 seventy-three. There is a body of engineer mechanicians, which had seventy-eight members in 1883. These machinists are trained in the school at Genoa, and they manage the engines of the fleet, which has now the largest ironclads in the world.

An examination of the courses of study at Toulon and Genoa shows that the French and Italians have adopted an effective system of supplying their fleets with practical machinists. The scientific-engineer corps are not open to

these machinists. The British system provides a small number of engineers for construction duties, and a body of well-educated engineers, in addition to engine-room artificers, for service afloat. It does not appear, however, that any country has settled definitively upon a plan of placing scientific engineers in the engine rooms of ships for watch duty; machinists seem to be preferred for that purpose.

THE CHAIRMAN.—*Gentlemen:*—The comprehensive character of the essay, at least so far as concerns the *personnel* of the service, together with its suggestions of many other subjects than those it considers at length, makes it a paper covering points upon some of which every officer has decided views. I think the character and extent of the discussion here to-night show this to be the case.

I shall limit my remarks in closing the discussion to two points. The first has been suggested by the remarks of Commander Hoff quite as much as by the essay. I refer to the duties of the "General Staff," as outlined by the author of the paper. We have no such office in the naval service, and the duties which belong to that office are not now performed. As the author states, the principal duty of such an office would be to prepare for war. In the sense in which the word "preparation" is here used, we are totally unprepared, and further than this, no provision is made that we shall prepare at any future time. It is not the specific duty of any one or any office to make such "preparation" as is here contemplated.

I cannot better explain my meaning, which I am confident was also the meaning of the author, than by an illustration: Suppose that war were declared between the United States and Spain, or Great Britain, or any other enemy or possible combination of them. I think it will be at once conceded that such a war must be largely, if not entirely, a naval war. To whom would we turn for advice and guidance? To whom could we turn? Is there an officer in the service, or does there exist any official authority, prepared to assume control and direct what is to be done, to say whether we shall act offensively or defensively? Would the President and his Cabinet decide such questions? Manifestly, the responsibility would rest there; but can the Cabinet be reasonably expected to be familiar with the numerous problems involved? It is the province of the statesman to anticipate the difficulties, and by his wisdom and firmness to prevent war; but when diplomacy has been superseded by a state of war, the military and naval service should be prepared to meet the new condition of affairs and carry them to a successful issue. Although the President and his Cabinet must bear the responsibility of the course adopted in case of war, they have a right to expect that the necessary technical knowledge will be at hand to assist in their councils. Now, I believe that the technical knowledge which would be required under these conditions could not be found.

Consider for a moment what is comprehended in proper preparation for war. Among other things, we should know the naval strength of our enemy, and this knowledge should be particular and specific as regards guns, armor, speed, and draft of water; we should know at all times the position of every portion

of this force; we should have a complete knowledge of the resources of our enemy—that is, his ability to increase his fighting powers in men, guns, and ships. We should know the position and condition of his coaling stations, the extent and character of his merchant marine and its lines of traffic. We should know the weak and strong points of his coast defense; the character of the defenses—whether guns, mines, or torpedoes, or a combination of these. We should know the character of his harbors and the location of all arsenals and storehouses.

It is needless to say that an equally particular and accurate knowledge of our own resources would be required. All this information can now be furnished by the Office of Naval Intelligence, and this knowledge of facts may be considered the tools with which the strategist may commence his work.

The accumulation of such information may be considered as the first step in the way of preparation for war. Next must follow a careful study of the whole field, to decide how most effectively to use our own force and most certainly to paralyze the efforts of the enemy. In case his fleet is scattered, we should aim to destroy it in detail. If an important port is without the necessary naval defense, it would be the time to concentrate upon it.

On the other hand, we should anticipate and provide for similar efforts being made against our own weak points. We should have exact knowledge of the internal state of the country of our enemy, as to whether the government is likely to be warmly supported under given conditions of warfare, or whether a decisive blow against him would awaken the patriotism of the people, or prematurely discourage them. We should know what nations would prove his allies under given circumstances, and the same knowledge of the strength and vulnerability of every possible ally must be, in like manner, studied. A little consideration will show that here is a vast field for study. It is not a subject that can be solved as one would solve a problem in science or a problem in chess. The student must have the whole resources of the Government at his command. It is the grand problem of war, and the elements which enter into it are widely varied, and in number equal to that resulting from the combination of all human passions and the material forces which act upon them. It will also be readily seen that the number of problems may be very great; the number of nations that may become our enemies, and the various combinations which might be formed against us, would make the number great.

To study and solve these problems would be the duty of the General Staff, as I understand that term. At any rate, it is the duty of the naval service to concentrate upon these questions the best ability and most painstaking thought possible. It is a large question; ample means and every facility should be provided by the Government to master it. And I am confident that those who will undertake this work will receive every encouragement when their aim is understood. It was to meet this want that the War College was founded. It was for the study of the science of war that this latest naval *school* was established. The scheme was to assemble a class of officers and propose such a problem as I have referred to—a war between the United States and another country—and develop a plan of action to be followed in the given case. After

studying the question in all its bearings, which might require months of reading and research, a perfected plan was to be drawn up and filed for future use. A plan of action in case of a war with one country having been decided, another country would be taken and studied in the same way, and a similar completed and detailed plan prepared. You may say that such plans must vary from time to time, as the factors vary. This is true ; but a careful plan would provide for many contingencies, and when any arose which had not been anticipated, the plan must be revised. An able chess-player forms his plan of attack and provides for his defense while he anticipates many possible moves. Something unforeseen may decide him to change his plan, but he must never be without one.

Such study as this will be an excellent school of preparation for war, and I believe that the plans resulting from this study would supply a great deficiency in our organization. Such study had not been undertaken elsewhere, and great credit is due the distinguished officer who recognized its need, and who has done so much to establish it. This scheme is not yet in working order, for, unfortunately, it has not been understood by the service, and (through misapprehension of its aims) it has been vigorously opposed. The War College is not a post-graduate course of the Naval Academy in the sense that it is a continuation of the instruction given here. It aims to teach, or, more properly speaking, to furnish facilities for the study of, subjects that are taught nowhere else. It is not a fanciful scheme to increase the book-knowledge and add to the already endless examinations of our naval officers, but it has been evolved from the necessities of the service.

When sharp and sudden war comes upon us there should be a well-considered plan of action to cover every probable condition of affairs, and there should be officers at hand whose study of strategical questions had prepared them to supplement, if necessary, the plan in question. If these plans were ready, and there were officers whose intelligence and skill in such matters were well known, their advice would be sought and followed when war came. If the number of ships and guns were small, the greater would be the necessity for such careful preparation, and the Navy would have done its part.

Nor would it be alone in time of war that such a state of preparedness would have its influence. In time of peace it would develop in the legislators of the country such a confidence in the foresight and wisdom of those controlling naval matters that they would trust their judgment and be guided by their advice as they have not been in times past.

Thus much I have said about the War College, and its functions in a proper organization of the naval service, because I fear that it has not been understood. I think it is our duty to encourage and advance it in all possible ways. It is not a rival of the Naval Academy ; it has a different field ; and I sincerely hope that those who have its affairs in charge will confine its work to the original plan, which comprehended the Science of War, International Law, and Naval History. This is a course which demands mature minds for its study.

The second point upon which I venture to remark, and this time to differ with the able author of the essay, concerns the education of our naval engineers, and the necessity for them in our naval organization. The author of

the essay, quoting, says: "A man-of-war's-man of to-day is not a mere seaman, but a trained warrior. He is an accomplished artillerist, a skilled rifleman, a trained swordsman, a practical electrician, and a superior torpedoist rolled into one"; and then adds: "This long list of accomplishments necessary for a modern man-of-war's-man shows how impossible it is to indulge in specialties on board ship." Admitting the necessity of this array of accomplishments—and I even think it should be materially increased in number—I would draw an entirely different inference from this necessity; in other words, the great variety of acquirements necessary among the officers of a ship shows how necessary specialists have become.

I think the soundness of this statement must be admitted, if we stop to consider how comparatively simple a machine a man-of-war was, even a few years since, as compared with the latest type of an ironclad man-of-war. If we could be assured that we had reached the end of development; that no other accessories would be added, that no other complications of machinery would be devised; that triple- or quadruple-expansion engines would not become necessary; that submarine warfare would not be added to the other means of attack; that the development of guns and torpedoes had reached a standstill; then we might each hope to become experts in every branch of our profession. But, far from any such assurance being possible, we know that the reverse will be true. Each day will see applied to our profession fresh principles of science and new applications of well-known principles. New engines of warfare will be invented, present ones will become greatly changed. Special types of ships will be built for special purposes, embodying special features, and to accomplish special ends; and this differentiation will be carried to a length that we cannot now anticipate. How, then, can we hope to keep pace with all these changes unless we divide up the work, as it were, so that our combined acquirements will cover all the ground? Much more difficult will it be to initiate and perfect these prospective improvements in our profession, except by encouraging specialties.

I do not wish to be understood as advocating a division of the officers of the line into corps, who shall each devote himself to a special branch of the profession and know nothing of the others. On the contrary, I think the acquirements of an officer ought to be extended, and should at all times comprise such a general knowledge of his profession as will enable him to fight his ship and use intelligently every appliance of it. But, above and beyond this, every officer should aim to be an expert in some branch of his profession in which he may act as a guide and critic for the service.

Consequently, if engineers were once useful to the service, they have now become necessary, and will be in the future indispensable. On the other hand, I am convinced that the number of non-combatants should be reduced to the smallest number consistent with the efficient performance of duty. On board of any ship the number of engineer officers should not exceed two. There is no necessity for marine officers, and probably no necessity for marines. The paymaster needs no clerk. One doctor is quite enough for most ships, and when there are two there should be no apothecary. These are a few of the reductions that should be made.

U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

ON THE STUDY OF NAVAL WARFARE AS A SCIENCE.*

"*Science is applied knowledge.*"

By Rear-Admiral S. B. Luce, U. S. N.

Under date of May 3, 1884, the Secretary of the Navy appointed a board of three officers to "report upon the subject of a post-graduate course for officers of the Navy."

The board so appointed met, and, after careful deliberation, reported, under date of June 13, that there was "not only a reason, but an *absolute necessity*," for the establishment of such a school as contemplated by the order, the report dwelling most particularly on the importance of the study of war and international law. Much stress was laid upon the subject of war as the leading study of the proposed school. The board expressed the opinion that "a cogent reason for such a school was that there might be a place where our officers would not only be encouraged, but *required* to study their profession proper—war—in a far more thorough manner than had ever heretofore been attempted, and to bring to the investigation of the various problems of modern naval warfare the scientific methods adopted in other professions." And this idea of the study of war according to a certain prescribed method pervades the whole report. It is the central idea of the plan of operations, the very cornerstone, as it were, of the War College.

The report of the board was adopted, and in October the Navy Department issued the following order:

* Introductory paper read at the Naval War College, Newport, R. I., Sept. 6, 1886.

"General Order No. 325.

"NAVY DEPARTMENT,
WASHINGTON, *October* 6, 1884.

"A college is hereby established for an *advanced course* of professional study for naval officers, to be known as the Naval War College. It will be under the general supervision of the Bureau of Navigation. The principal building on Coasters' Harbor Island, Newport, R. I., will be assigned to its use, and is hereby transferred, with the surrounding structures and the grounds immediately adjacent, to the custody and control of the Bureau of Navigation for that purpose," etc., etc.

"WILLIAM E. CHANDLER,
Secretary of the Navy."

No immediate steps, however, were taken to carry out the order.

During the Second Session of the Forty-Eighth Congress the Senate adopted a resolution (Feb. 4th) calling upon the Secretary of the Navy for information in regard to an advanced course of instruction for naval officers. In answer the Secretary wrote, under date of February 11, 1885, as follows: "The reasons which have controlled the action of the Department are to be found in the recognized necessity for *an advanced course of military and naval education* in the United States. There are now existing three schools for the purpose in the Army and one in the Navy. The latter is at the Torpedo Station at Newport, where a class of officers is assembled for a few months in each year for instruction in the art of manufacturing and using torpedoes and torpedo explosives. The constant changes in the methods of conducting naval warfare imposed by the introduction of armored ships, swift cruisers, rams, seagoing torpedo-boats and high-power guns, together with the more rigid methods of treating the various subjects belonging to naval science, render imperative the establishment of a school where our officers may be enabled to keep abreast of the improvements going on in every navy in the world. The Torpedo School only partially fulfils the imperative requirements. The College is intended to complete the curriculum by adding to an extent never heretofore undertaken the study of naval warfare and international law and their cognate branches." (See Senate Ex. Doc., No. 68, Forty-Eighth Congress, Second Session.) From this it would appear that the War College is not, in the estimation of the Department, for a post-graduate course merely, as that term is generally understood,

but for the higher and much more comprehensive purpose of a greatly advanced course of professional instruction.

Now, it must strike any one who thinks about it as extraordinary that we, members of a profession of arms, should never have undertaken the study of our real business—war. For members of the naval and military profession it should be not only the principal study, but it should be an attractive study. War has been called a game, and as a game it possesses great interest to a majority of men, while to a certain order of minds it has a positive fascination.

We find in civil life men who love to study the campaigns of the great captains of history ; who read the life of Alexander the Great, made up wholly of his campaigns, with the eagerness others peruse the pages of romance, and who follow Cæsar through Gaul, and Hannibal across the Alps, with the keenest interest. No one can read the series of manœuvres, the play and counter-play of Turenne and his great opponent, Montecuculi, resulting in the untimely death of the former, without a thrill of admiration for the skill displayed by these two well-matched adversaries. And, although confined entirely to the land forces, such campaigns are replete with valuable lessons to the naval officer. Marlborough, Frederick the Great, Napoleon, Wellington, and many of the great military leaders of our own country, have left us a rich legacy of many a skillfully played game which furnishes practical illustrations of great principles. It is for us, here and now, to familiarize ourselves with those principles, that we too may be ready to apply them when called upon to take a hand in the game.

Now, science is contributing so liberally to every department of knowledge, and has already done so much towards developing a truer understanding of the various arts, including that of the mariner, that it seems only natural and reasonable that we should call science to our aid to lead us to a clearer comprehension of naval warfare, as naval warfare is to be practised in the future. Steam tactics and naval warfare under steam are comparatively new studies, and readily admit of modern and scientific methods of treatment. The formation of the line-of-battle, composed of large ironclads, carrying heavy guns and auto-mobile torpedoes, the use of the ram as an independent arm, and the seagoing torpedo-boat and its place in the order of battle, are subjects which require the most careful consideration, and may well excite on the part of the naval officer, indeed *should* excite, an intelligent curiosity or inquisitiveness.

Indeed, we may go further, and say that the naval officer who does not seek to inform himself on these points is indifferent to the most important branch of his profession. That the whole subject is new and fresh and worthy of our most careful study is to be learned from the fact that the great naval powers of Europe still regard steam tactics as an unsolved problem. Thus we have the charm of novelty in our researches and a stimulant of a happy solution of a great problem.

What we need is, first, a clear conception of the problem itself, and then a solution of it so grounded in immutable principles as to admit of no doubt of its correctness. But it may be asked, "What is science?" and "How are we to regard as a science naval warfare, with all its various and complicated conditions?" and "How are we to treat such a subject in a scientific manner?"

In order to answer this very natural question, let us first understand what is meant by the word "science." Webster defines science to be "knowledge duly arranged, and referred to general truths and principles, on which it is founded, and from which it is derived." "In point of form," says Sir William Hamilton, "it has the character of logical perfection, and in point of matter the character of real truth."

"A science," says Dr. Francis Lieber, "is a branch of knowledge or collection of ideas systematically developed according to principles peculiar to the subject-matter itself. A science is independent within its own sphere. Everything is worthy of being scientifically investigated; that is, worthy of being investigated as to its essentials, separately and for itself, with a view of arriving at principles and laws. Every principle and law thus arrived at extends the sphere of knowledge, expands the human mind, increases the stock of civilization, and is emphatically useful."

Buckle defines science as "a body of generalizations so irrefragably true that, though they may be subsequently covered by higher generalizations, they cannot be overthrown by them; in other words, generalizations which may be absorbed, but not refuted."

Both of the two last definitions may be illustrated by the history of the development of the physical sciences. By a series of experiments in chemistry many interesting and useful facts were discovered; but it was not till the generalizations of Lavoisier linked those facts together that the laws which govern the properties of matter were brought out. It was by this inductive method that chemistry was raised to a science.

In its earlier history geology was a crude mass of independent facts. But Cuvier applied to the study the generalizations of comparative anatomy, and co-ordinated the study of the strata of the earth with the study of the fossil animals found in them. Thus he was the founder of the science of geology.

Astronomy furnishes a still more forcible illustration. Hipparchus, Ptolemy, Copernicus, and Galileo, each in his own time, made certain discoveries and demonstrated certain truths in relation to the movements of the heavenly bodies, and of the earth itself. And Tycho Brahe, the Dane, far exceeded them all in the vast accumulation of observations of the stars. He undertook, in short, to catalogue the fixed stars, a labor originally essayed, though in a much ruder manner, by Hipparchus. But while Tycho Brahe himself knew not the real value of his own work, Kepler, generalizing from the great mass of observations, was led to the discovery of those three great laws relating to the planetary system which won for him the proud title of "Legislator of the Heavens" and opened the way for the final generalizations of Newton.

Taking its rise in the fanciful dreams of astrologers, astronomy has now become the most exact of all sciences. "By employing the deductive weapon of mathematics we can compute the motions and perturbations of the heavenly bodies; and by employing the inductive weapon of observation the telescope reveals to us the accuracy of our previous and, as it were, foregone inferences. The fact agrees with the idea; the particular event confirms the general principle; the principle explains the event; and their unanimity authorizes us to believe that we must be right, since, proceed as we may, the conclusion is the same; and the inductive plan of striking averages harmonizes with the deductive plan of reasoning from ideas."*

Now, naval history abounds in materials whereon to erect a science, as science has been defined and illustrated, and it is our present purpose to build up with these materials the science of naval warfare. We are far from saying that the various problems of war may be treated as rigorously as those of one of the physical sciences; but there is no question that the naval battles of the past furnish a mass of facts amply sufficient for the formulation of laws or principles which, once established, would raise maritime war to the level of a science. Having established our principles by the inductive process, we may then resort to the deductive method of applying those princi-

* Buckle's History of Civilization in Europe.

ples to such a changed condition of the art of war as may be imposed by later inventions or the introduction of novel devices.

For a very simple and obvious illustration we may take the state of shipbuilding during the early and middle parts of last century. The French ships-of-war were of superior model and their bottoms were sheathed with metal. The English ships-of-war were of inferior model and were not sheathed. The natural result was a constant gain of advantage in their sea fights of the former over the latter. The English ships were, on certain momentous occasions, so greatly retarded in their movements by the accumulation of marine growth, and their indifferent sailing qualities were of such great and manifest disadvantage to them in battle, and the fact is so often made a matter of historical record, that, by the method of generalization, we are enabled to lay down the broad principle that *speed is an essential element in naval warfare*—an axiom not needing an elaborate argument, but given as an illustration. This is the inductive system of proceeding from particulars to generals.

By reversing the operation and applying the deductive method of proceeding from generals to particulars, we deduce from the principle just stated the fact that the modern war ship must be modeled with special reference to speed, and must have her bottom protected from the fouling due to vegetable marine growth. Thus we arrive at a fundamental truth; and to disregard such teachings is not merely to commit a great blunder by shutting our eyes to the lessons of history, but it is to be unscientific in one's own profession, which, in these days, is to be culpably ignorant, if not criminal.

Nor are we obliged to go very far back for many important facts in regard to maritime war, on which we are to generalize. In our own very limited experience in war the battle of Port Royal furnishes a valuable illustration of the necessity of possessing a secure base of supplies within the theatre of war, and few naval conflicts have been so pregnant with results as that in which the monitor bore so conspicuous a part. As an illustration of that very important military element called the *moral effect* of a battle, it stands almost unrivaled.

The grouping together of a number of important facts gathered from the accounts of naval battles will enable the naval student who has acquired the habit of generalizing to lay down principles for his own guidance in war, and that is a work that each one can do for himself better than another can do for him. The passage from facts to principles in induction in its highest form is inspiration, says Tyndall.

Again, it has been said that the philosophy of method bears the same relation to science that science does to art. "The progress of every science is affected more by the scheme according to which it is cultivated, than by the ability of the cultivators themselves." Some men, like Tycho Brahe, without a Kepler to follow, "have consumed their lives in fruitless industry, not because their labors were slack, but because their method was sterile."

Hence, to elevate naval warfare into a science, as we now propose doing, we must adopt the comparative method; and, as Cuvier co-ordinated the study of geology with that of comparative anatomy, so must we co-ordinate the study of naval warfare with military science and art. That is the theory on which we are now to proceed; and it is desirable that each one of us should comprehend this theory in its length and breadth, its height and depth, for it is on such perfect understanding alone that success in our present undertaking can be assured. It is by the comparative method that we have been led to a knowledge of the most important phenomena of the science of life. As it would be impracticable to study the living action of the various organs of the human body, the physiologist has recourse to other means whereby to carry on his investigations. All vertebrate animals, being constructed on the same general plan of organization, with corresponding organs of the same character common to all—their nervous and vascular systems, digestive apparatus, organs of locomotion, and the rest—can easily be recognized and compared with each other. From the study of the brain of a pigeon, for example, Dalton was enabled to explain the functions of the human brain. From experiments on the horse, Matteucci demonstrated the rapidity of the circulation of the blood. Brown-Séquard and Velpeau, by experiments on animals, discovered the functions of the spinal cord. Bidder, Schmidt, and Dalton illustrated the process of digestion by experiments on dogs; and the action of the heart and the circulation of the blood were, by the same process, illustrated by Harvey. This gives us a hint pregnant with possibilities.

We have already referred, in passing, to the splendid results achieved by Cuvier through his adoption of the comparative method of investigation. Says Buckle: "By this union of geology and comparative anatomy, there was first introduced with the study of Nature a clear conception of the magnificent doctrine of universal change, while at the same time there grew up by its side a conception, equally steady, of the regularity with which the changes are accomplished, and of the undeviating law by which they are governed."

In his beautiful eulogy on Agassiz, Professor Le Conte, in explaining the comparative method of investigation (for the more general introduction of which he gives the great scientist high praise), says: "Anatomy only becomes scientific through *comparative* anatomy; physiology only becomes scientific through *comparative* physiology"; and we may add, without distorting the parallelism, that naval tactics, using that word in its more extended sense, becomes scientific only through *comparative* tactics. For, having no authoritative treatise on the art of naval warfare under steam, having no recognized tactical order of battle, being deficient even in the terminology of steam tactics, we must, perforce, resort to the well-known rules of the military art with a view to their application to the military movements of a fleet, and, from the well-recognized methods of disposing troops for battle, ascertain the principles which should govern fleet formations. Thus, from the known, we may arrive at something like a clear understanding of what is now mere conjecture. *It is by this means alone that we can raise naval warfare from the empirical stage to the dignity of a science.*

It is important that this should be understood. We lay so much stress upon this method of treating our subject that, even at the risk of overburdening the argument, let us refer once more to the methods of investigation pursued by the most advanced thinkers of the age. We have drawn our illustrations so far from the physical sciences. Let us now go to other departments of learning, and we shall see what the comparative method has done for them.

"It was supposed at one time," says Max Müller, "that a comparative analysis of the languages of mankind must transcend the powers of man; and yet, by the combined and well-directed efforts of many scholars, great results have been obtained, and the principles that must guide the students of the science of language are now firmly established.

"It will be the same with the science of religion. By a proper division of labor, the materials that are still wanting will be collected and published and translated; and when that is done, surely man will never rest till he has discovered the purpose that runs through the religions of mankind, and till he has reconstructed the true *Civites Dei* on foundations as wide as the ends of the world."

It has been by treating the subject of religion in a scientific manner that deep and hidden truths have been revealed, and passages of the Holy Scriptures otherwise obscure have been rendered clear and

full of meaning. Thus, as the author says, "the science of religion will for the first time assign to Christianity its right place among the religions of the world; it will show for the first time what was meant by 'the fullness of time'; it will restore to the whole history of the world, in its unconscious progress towards Christianity, its true and sacred character."

Speaking in another place of the science of language, he says: "People ask, 'What is gained by comparison?' Why, all higher knowledge is gained by comparison, and rests on comparison. If it is said that the character of scientific research in our age is pre-eminently comparative, this really means that our researches are now based on the widest evidence that can be obtained, on the broadest inductions that can be grasped by the human mind." "What can be gained by comparison?" he asks again. "Why, look at the study of languages. If you go back but a hundred years and examine the folios of the most learned writers upon questions connected with language, and then open a book written by the merest tyro in comparative philology, you will see what can be gained, what *has been* gained, by the comparative method." Reasoning thus, he advocates the comparative or scientific study of the religions of the world.

Lastly, we have the authority of Mr. Hutcheson Macaulay Posnett, who, in his *Comparative Literature*, says: "The *comparative method* of acquiring knowledge is . . . the peculiar glory of our nineteenth century."

Hence, we have not only comparative anatomy and comparative physiology, but comparative philology, comparative grammar, comparative religion, comparative literature, and why not, we ask again, comparative war, or a comparative study of the military operations of a sea army and a land army? Attention has been called repeatedly by various writers to the close analogy between military and naval operations. It has been successfully shown that among the ancients, or what has been termed the "oar period" of naval history, the military and naval tactics were as nearly identical as the nature of the elements would admit. The most distinguished soldiers of Carthage, Greece, and Rome commanded afloat, as occasion required.

Macaulay, in speaking of the English Navy of the time of Charles II., says: "No State, ancient or modern, had before that time made a complete separation between the naval and military services. In the great civilized nations of the old world, Cimon and Lysander, Pompey and Agrippa, had fought battles by sea as well as by land.

Nor had the impulse which nautical science received at the close of the fifteenth century produced any material improvement in the division of labor. At Flodden the right wing of the victorious army was led by the Admiral of England. At Jarnac and Mon-Contour the Huguenot ranks were marshaled by the Admiral of France. Neither Don John of Austria, the conqueror of Lepanto, nor Lord Howard of Effingham, to whose direction the marine of England was entrusted when the Spanish invaders were approaching its shores, had received the education of a sailor. Raleigh, highly celebrated as a naval commander, had served during many years as a soldier in France, the Netherlands, and Ireland.

"Blake had distinguished himself by his skillful and valiant defense of an inland town before he humbled the pride of Holland and of Castile on the ocean.

"Since the Restoration the same system had been followed. Great fleets had been entrusted to the direction of Rupert and Monk—Rupert, who was renowned chiefly as a hot and daring cavalry officer, and Monk, who, when he wished his ship to change her course, moved the mirth of his crew by calling out, 'Wheel to the left!' Coligny was a colonel of infantry when, in 1552, he was made Admiral of France, and distinguished himself at the battles of Dreux and Jarnac, and James II. served in the French army under Turenne, and received a thorough training as a soldier, before he was called upon to command the Channel fleet during one of the great Dutch wars."

About 1672 the French began to educate young men of good family especially for the sea, and England soon followed the example. In the process of time the two professions, the naval and military, became so distinct that everything of a military character began to be looked upon with contempt by those bred to the sea. The very name of "soldier" became among sailors a term of reproach, and when troops of the line were first placed on board ship they were made the subjects of endless ridicule among the rollicking sailors. Even to this day the older class of seamen despise "sojering," and look with contempt upon a "musket." This feeling was not confined to the seamen. It was shared by the officers, who prided themselves on their practical seamanship, and held military matters as beneath their notice. We have now reached a stage of progress which enables us to take such a broad and comprehensive view of nautical science as to avoid either of these extremes. While educating officers especially for sea service, they are yet taught the

military character of their profession; and the close analogy between the operations of a fleet and an army has long been insisted upon, and is now generally acknowledged.

Even under sail tactics Paul Hoste, and, later, John Clerk, the author of the "Essay on Naval Tactics," noticed the military character of fleet evolutions. It is not surprising, therefore, that early in the history of steam tactics there should have been a number of writers who called attention to the same fact. Admiral Bowles, R. N., remarked that we had "arrived at a new era, in which steam would enable naval commanders to conduct their operations on military and scientific principles," and Admiral Dahlgren observed that the principles of military tactics would hereafter enter largely into the manœuvres of a fleet. Sir Howard Douglas, referring to these several authorities, adds that "the celerity and precision with which steam fleets may execute any evolution whatever will hereafter allow the principles of tactics on land to be applied to the movements of ships on the ocean, with this advantage on the side of naval operations, that the inequalities of ground which so seriously embarrass the manœuvres of troops do not exist at sea." This is quite true. The movements of an army may be, and very often are, obstructed by the physical conditions of a country; mountains, rivers, and forests must often be taken into account in planning a campaign, and the lines of communication with the bases of supplies, the lines of retreat, and the topography of the country within the field of operations must necessarily control the question of the proper distribution of troops for battle. None of these elements enter into the discussion of the operations of a fleet.

But beginning with the terminology of elementary tactics, and passing thence through the school of the battalion to grand tactics, and, finally, to strategy, it will be found that there is so much that is common to both the land and the sea forces, that we may by the comparative method, readily and intelligently, not only formulate correct theories in regard to naval warfare under steam, but confidently lay down unerring principles for our guidance in the conduct of battle. Commodore Parker's "Fleet Tactics under Steam" is, as he himself tells us, "simply an adaptation of military to naval tactics." Woods Pasha, in a recent article on the naval tactics of the future, says: "It is hardly possible to glance at the development of the modern fighting ship without being struck by the analogy between military action afloat and ashore." Indeed, it would help

very materially in our investigations if we kept prominently in view that word *milites*, signifying fighting men, and thus have constantly before us the military character of our profession. We might then consider a fleet as a sea army, as the Latin races do, and adopt without reserve, as far as applicable, the tactical movements of the land forces for the management of an assemblage of ships-of-war. Such a step would have the advantage of clearing away or disposing of a great deal of useless material left over from the sail period, and enable us to bring to the consideration of our subject minds unembarrassed by obsolete formularies.

It would far exceed the limits of this paper, which is intended to be merely introductory, to point out in detail the close analogy between the operations of land and sea forces. Many illustrations will doubtless suggest themselves to the naval student who reads military history, and it is especially recommended that the members of the class under instruction should, each one for himself, as we pass through the course of lectures on military science, note the points of analogy as they come up and make careful memoranda of those principles of military movements which are applicable to a floating force.

By way of illustrating our meaning more clearly, we may give a few examples of the more obvious principles common to both services. Guibert, an eminent French writer on military science, has said that the art of fortification and that of field tactics are intimately connected with each other, and that the latter derives many of its principles from the art of constructing permanent fortresses. In both the important object is to dispose the parts, whether works or bodies of troops, so that they may afford mutual protection. He infers, therefore, that to be a good tactician a knowledge of military engineering is necessary. Now, these remarks apply with equal force to the naval tactician, for he too should so dispose the ships of his fleet that they may mutually support one another. Ships may be regarded as movable forts, and reasoned upon accordingly. "The inartifical practice," says Sir Howard Douglas, "of forming a fleet for battle in one long line, in which the ships are devoid of the power of protecting each other by reciprocal defense, and without a second line as a reserve, ought to be abandoned, as a corresponding practice with armies in the field has been renounced in warfare on land." The advantages of the *echelon* formation for an army and its application to a fleet have been so fully and ably set forth by Sir Howard

Douglas as to leave nothing to be added. The most striking illustration, however, is to be found in that peculiar method of attack to which Napoleon owed many of his victories on land and Nelson on the sea. It is expressed in that maxim which teaches the importance of so conducting a battle as to bring upon the point of attack a great superiority of force in such a manner that the enemy, even if numerically superior upon the whole, may be unable to succor the part so overpowered. The late Captain James H. Ward, U. S. Navy, in commenting upon this point, says that this same maxim, so fully recognized by military writers, was in the contemplation of Byng in 1756; of Hood at Basseterre Roads (St. Kitts), 1782, and was carried out by Rodney in his chase of the French in 1782; by Nelson at the Nile and at Trafalgar, and in a most remarkable manner by Perry at Lake Erie.

We have already laid down as a principle in naval warfare, clearly established by the method we have adopted for our investigations, that "speed is essential to success in war." This is true also in military science. Marshal Saxe declared that "success in war is due to the legs of the soldiers." The rapid marches which preceded the battles of Gunzburg and Elchingen, we are told, were the causes of the successes of Napoleon much more than those combats, brilliant as they were. To the bold and rapid movements which characterized the campaigns of Alexander the Great, Cæsar, Hannibal, Frederick the Great, and Napoleon are to be attributed their uniform successes.

But there was a certain mobility, as distinct from speed, peculiar to the troops of Napoleon, which rendered them easily handled by a master of the art of war. This too is an important quality in ships. It was the speed and activity of the Greek triremes that led to their victory at Salamis. It was to the light, swift, and quick-turning Liburnian galleys that Octavius owed his victory at Actium. The Spaniards of the Invincible Armada were astonished by the speed and handiness of the English ships they encountered in the Channel. The Duke of Medina-Sidonia said they seemed to leave the Spanish ships and approach them at pleasure. In one of his plaintive letters to Parma he wrote: "We cannot bring the English to battle, for they are swift and we are slow." The wretched sailing qualities of the Spaniards and their unwieldiness put them at a disadvantage for which skill and courage could not compensate.

Now, speed is a comparative quality. The English ships of that day,

though fast when compared to the Spanish ships of the Armada, were slow when confronted later on with the superior models of France. It was during the greater part of the eighteenth century that the speed and handiness of the French ships-of-war enabled the French admirals to practise those tactics which so long rendered the high fighting qualities of the English of no avail. To the quality of speed, then, we must add, as another deduction, the quality of mobility, handiness, or the property of quick turning. The ocean racers of the great Transatlantic lines, with lengths ten, and often eleven, times their beam, have great speed, but very limited powers for quick turning.

There is still another quality of speed, or, more properly speaking, celerity of movement (if we may make the distinction), which is common to both land and sea forces, but which belongs more to the personal character of the commander-in-chief than to the troops or ships under his command. "It was not the Roman army which conquered Gaul, but Cæsar," said Napoleon. "It was not the Carthaginian army which made Rome tremble at her gates, but Hannibal. It was not the Macedonian army which marched to the Indus, but Alexander. It was not the Prussian army which defended Prussia for seven years against the three most powerful states of Europe, but Frederick." The wonderful success of these great captains was due in a very large measure to the continuous celerity of their movements, to their great energy governed by an intelligent directive force.

In 1781 the English fitted out an expedition to capture the Dutch Colony at the Cape of Good Hope. De Suffren sailed shortly afterwards from Brest (March, 1781), fell upon the English squadron under Commodore Johnson, at Porto Praya (Cape de Verde Islands), and after a drawn battle hurried on to the Cape of Good Hope, where he arrived one month in advance of the English, thus fully securing the object of his mission, which was to thwart the designs of colonization by the English in that quarter. History is replete with such examples of celerity of movements both in the land and in the naval service.

Nelson's chase of the French squadron under Villeneuve forms a chapter in itself. In connection with mobility of the units of organization must be considered still another element of success common to both services, the potency of drill. The talents of the naval architect and the skill of the marine engineer and the labors of the ordnance officer will have been put forth in vain, if the squadron of fighting ships be not in efficient discipline and thorough drill. History teaches no more important lesson than this, and here again the two armies

stand on common ground. The Romans called an army *exercitus*, which also meant exercise. What a history in that one word! Frederick the Great paid more attention to mere parade drill than any modern general, to which fact he owed many of his victories, as well as his escapes from serious disasters.

"Unquestionably," says one military authority, "of two armies equal in all other respects, and equally handled by their commanders, that one must win which can manœuvre with the greatest rapidity and precision." And one of the most distinguished writers of the day on naval matters says, in speaking of the necessity of a school of practice in naval tactics, "The fleet most thoroughly drilled in naval tactics will have the greatest advantage in war."

To say that "speed," "handiness" and "drill" are elements essential to success in war, seems to be stating such self-evident truths as to need no demonstration. That may be true, but it is equally true that the examples of history which inculcate these lessons are being disregarded every day by nearly all maritime powers, and by none more than our own. They are of that class of truths which everybody admits, but nobody heeds. A certain English essayist says that "the best way of introducing any subject is by a string of platitudes delivered after an oracular fashion." We have taken the hint.

Captain Maguire, U. S. Army, following Guibert, shows the analogy between land and sea forces from the point of view of a military engineer. In speaking of the attack of forts by ships he says: "This attack by sea may be compared to a land siege. The fleet will first bombard the sea forts at long range, in order to silence their fire; thereupon it will approach nearer to the coast forts and batteries, in order to carry on with favorable chances the decisive fight intended for the complete subjection of the latter. Finally, it will turn its attention to those works more retired which bear upon the harbor entrance and its obstructions. This last act may be considered as entirely identical with the heavy and rapid fire of the siege batteries, which precedes the advance of the storming party. In case the obstructions consist of submarine mines, and the fleet must destroy them by torpedoes, this operation is identical with the counter-mining operations of a siege. Finally, as the storming of the breach is the crowning act of the siege, so must, or should, at least, the forcing of the harbor entrance be regarded as the last stage of the attack.

"This comparison leads us to the conclusion that the general

principles of sieges may be applied to attack by sea. In place of the ground in front of the works to be attacked lies the sea, which, with its depths and shoals, rocks, islands, wide and narrow channels, represents the more or less favorable field of operations of the attacking party; while the powerful ships, in consequence of their armor, are very strong batteries, which, after being once completely equipped, need no subsequent aid, and, in consequence of their engines, can constantly and rapidly change their positions.

"The ammunition supply of the ships will limit their action against a sea fort to the duration of a few days; and this, in connection with their great mobility, will give to the attack the characteristics of a short, rapid engagement."

But enough has been said to show the close analogy between the land army and the sea army to render further illustration unnecessary.

Having shown the system by which it is proposed to conduct the course of study in naval warfare, it is but just and proper to state, at the outset, that we are without instructors or even text-books. This should be distinctly understood. But we have an instructor in naval history to tell us some of the great lessons of the past; and we have an instructor in military science to teach those of us who are willing to learn what he knows of the general principles of that science. It is our part to learn what we can of them, to draw our own conclusions and to make our own deductions, and to apply the principles which they illustrate by the operations of past wars, both at sea and on land, that we may formulate our own ideas on the subject of naval warfare. By doing this we adopt the *comparative method.*

It is obvious from what has just been said that, while learning naval history and the military art and science from professors of those branches, we must be our own instructors in the naval art and science. Says President Bartlett, of Dartmouth College, in the *Forum* for September: "All higher education is essentially self-education. Teachers do not make the scholar. The impulse comes chiefly from within, and the student becomes the scholar when he ceases to confine himself to prescribed tasks or previous limits, and spontaneously reaches out beyond." If we are to learn this highest, noblest branch of our profession at all, we must be our own teachers, for as yet the science has no professors. We are the pioneers. Not only is it true that we have neither instructors nor text-books on naval warfare under steam, but there are no foreign navies to which we

can turn with confidence for instruction. In many of the essentials of an efficient navy, nearly every other maritime country has left us all but hopelessly in the rear. But in the theoretical knowledge of naval tactics under steam, it may be said that we all stand on common ground, with this advantage in our favor—that we are untrammeled with the traditions and formularies of an extinct period of tactics, and are, so far, free to prepare ourselves for a new study.

Let us glance for one moment at the state of "naval warfare under steam" as it was understood in England up to a very recent period. In an article on "Naval Tactics" which recently appeared in one of the most influential of the English reviews occurs the following: "There appears to be a pretty unanimous agreement, on the part of all those who have made naval tactics a subject of study, that the art has, in its revived form, scarcely advanced beyond the merest rudimentary conditions of existence. It is impossible not to be struck by the strange singularity of such a fact, if fact it be." We may here interject the remark that it *is* a fact.

"In an age in which the greatest scientific skill and mechanical ingenuity have been unreservedly exerted in perfecting the warlike efficiency of the military marine, the one art needed to develop to its fullest extent that truly wonderful efficiency has been strangely neglected and overlooked.

"The great tactical revolution caused by the introduction of steam propulsion has been either quietly ignored, or its extreme significance has been left to be pointed out by a small company of prophets, who have not, as yet, succeeded in gaining more than a partial hearing for the statement of their views." And further on the author remarks: "It is somewhat humiliating to reflect that, as yet, in spite of the immense progress made in every other branch of the naval art, the very stones wherewith to raise our tactical structure are, as has been well said, still unhewn. Some malignant fairy appears to have been slighted at the birthtime of that mighty fleet (the English Channel Squadron and steam reserve combined in 1872) which has won the admiration and has become the model of all the navies of the world. It possesses all the elements of perfection, but lacks one gift—the power to use it with effect." And the writer concludes: "We have as yet found out no proper system of tactics, *not because the invention of one is impossible*, but *because we have neglected to follow the roads which lead to it.*"

This is certainly very plain language, but we believe it to have

been absolutely true at the time it was written, some fourteen years ago—1872.

We may now come down to 1880. The Naval Prize Essay of 1880, by Captain the Honorable Edmund R. Freemantle, R. N., is still fresh in our memory. "If," says that able essayist, "we attempt to derive inspiration from the numerous naval writers who have studied the subject of a naval engagement between ironclads of the present day, we are startled at the wide difference of opinion expressed, not only as to the strength of various formations, but as to the manner of fighting which will be adopted. As a rule, strong assertions have been made and decided opinions given, based on necessarily weak arguments and weaker facts.

"A very general belief, shared apparently by foreign writers, has been that fleets will clash together in 'line abreast,' and that they will subsequently pair off to decide the action, forming a series of independent duels." Some of the best of the English naval essayists represent the "line abreast," as they term the line, as a very weak tactical formation. "On the other hand," he continues, "we have foreign authorities advocating the 'line abreast' as the only effectual tactical formation, and objecting to the inherent weakness of the 'line ahead' (column); while the English naval writer who has given most attention to the subject (Captain Colomb) prefers the 'line ahead' to any other combination." The group system of Bouet-Willaumez, the essayist treats with scant favor, though so strongly advocated by others. "The disagreement," he adds, "is not so much in the end sought for as in the means of attaining that end, Captain Colomb relying mainly on the GUN; the French writers mainly on the RAM." Now, as Captain Freemantle's essay received the prize, and as he exhibits the utmost familiarity with the Signal Book and the Manual of Drill, for neither of which he seems to entertain much respect, we may assume that he fairly represents the state of naval tactics in the English Navy of to-day, and that, to use his own language, they are still "groping in the dark."

It is plain there is little to be hoped for there. The French Navy is pretty much in the same category. Where, then, shall we look for light but to ourselves?

The position of our Military Instructor, it is hardly necessary to explain, is one of extreme delicacy. Entering upon an entirely novel undertaking, and thrown, I will not say among strangers, but among officers of another profession, it were singular, indeed, did he find himself wholly free from embarrassment.

Lieutenant Tasker H. Bliss, 1st Artillery, U. S. Army, an officer who stands deservedly high in his own profession, has kindly consented to give us his time and his best endeavors to render his department of this Institution worthy of the profession he represents. He fully understands the theory on which our studies are to be conducted. He is not here to teach us *our* profession, as has been vainly imagined. Knowing little of our profession, he is here to teach us what he knows of *his own* profession. Let us co-operate with him, then, and by our attention and application attain such good results as to prove that comparative tactics is the true scientific method of studying naval warfare under steam.

We cannot close this paper without one or two allusions to the lessons of history which seem most pertinent to our subject. It has often been observed that the ancient Greeks are our masters in the art of war. The Greeks were so convinced of the necessity of the study of theory, and of the insufficiency of practice alone, that they instituted public schools where they taught upon fixed principles and rules the science of war. The Spartans, we are told, were the first who formed their tactics into a regular system, to be taught as a part of education. Other nations imitated the Greeks. Princes and states maintained, at their own expense, either military academies or skillful professors of tactics for instructing in the theory those young men who devoted themselves to the profession of arms.

The Greeks reduced the whole of the science to calculation and rule. This precision carried the military art among them at once to a high degree of perfection. "The Greeks," observes one military writer, "although they made their tactics the basis of the science of war according to examples given by their masters in the schools, nevertheless considered this as composing but a small proportion of the acquirements necessary to a general. The art of commanding an army was justly considered as a most important part of knowledge, and was taught accordingly. This embraced all the grand objects connected with war."

The story has often been repeated of Hannibal having ridiculed one of those professors of tactics who, with pencil and tablet in hand, had the assurance to debate with him upon the operations of war. ("The Military Mentor," Salem, 1808.) But the wisdom of the Greeks in establishing a regular system of military instruction rests upon too solid a foundation to be shaken by any such anecdote. Besides, Hannibal himself had enjoyed unusual advantages in respect to mili-

tary education. He was early trained in arms under the eye of his father, Hamilcar, and probably accompanied him in most of his campaigns in Spain. He was certainly with him in the battle against the Vettones, in which Hamilcar perished, Hannibal being at that time but 18 years of age.

We do not find in history any mention made of naval schools among the ancients, but there is every reason for believing that the large fleets of galleys common to ancient Greece and Rome were fought by military men according to the military tactics of the times. The rules of the art of war, as then understood, comprehended both the land and the sea forces.

Here, then, is the philosophy of history teaching us by great examples. Inspired by the example of the warlike Greeks, and knowing ourselves to be on the road that leads to the establishment of the science of naval warfare under steam, let us confidently look for that master mind who will lay the foundations of that science, and do for it what Jomini has done for the military science.

U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

THE FIRING OF HIGH EXPLOSIVES FROM GREAT GUNS.

By Commander Albert S. Barker, U. S. N.

As the subject of firing high-explosive shells from great guns is engaging the attention of many at the present time, I have thought it well to follow the advice of my friend Professor Munroe, who has himself published so many valuable "Notes on the Literature of Explosives," and to place on record a correct history of the first successful attempts ever made in the United States (so far as known) to fire dynamite in shells from great guns, together with my views on the subject as officially expressed at intervals during the last twelve years.

These experiments prove, so far as a limited number can be relied on to prove anything:

1st. That dynamite can be safely fired from great guns in shells without extra precautions being taken to reduce the shock of discharge.

2d. That the ordinary Bormann fuse will explode dynamite shells.

3d. That howitzers or guns of small calibre can be employed to throw cases of dynamite or gun-cotton against vessels regardless of the ordinary devices used to protect ships from torpedo attacks.

One of the chief sources of apprehension in the use of high explosives for charging projectiles arose from the fact that it was believed that the highly sensitive fulminate-of-mercury fuse was necessary for its complete explosion.

On the 18th of May, 1874, while at the Torpedo Station, certain experiments—made, I am quite sure, at the suggestion of Professor Farmer—seemed to prove that a simple gunpowder fuse would detonate nitroglycerine and dynamite if either the gunpowder or the high explosive were confined in a strong metallic case. The following are the experiments referred to:

1st. Some yarns were soaked in nitroglycerine, and the platinum wire of an ordinary station fuse connected to a Farmer machine was laid on them. The wire was melted and the yarns were set on fire, but the nitroglycerine did not explode.

2d. The platinum wire of a fuse was put into nitroglycerine. The wire was melted, but the nitroglycerine neither burned nor exploded.

3d. Same as No. 2, except that the wire was longer. The nitroglycerine neither burned nor exploded.

4th. Two pieces of No. 36 platinum wire two inches in length were placed in a dish containing nitroglycerine. The wire was melted as usual by the use of the Farmer machine, but the nitroglycerine was neither set on fire nor exploded.

5th. One inch of platinum wire was laid on some yarns saturated with nitroglycerine. The wire was melted and the yarns were set on fire, but there was no explosion.

6th. One and a half ounces of nitroglycerine were placed in an iron tube, and a Stowell metal fuse of rifle powder was used. The nitroglycerine *detonated*.

7th. One and a half ounces of nitroglycerine were put in a tin tube, and an ordinary station fuse of rifle powder, in a wood case, was used. The nitroglycerine *detonated*.

8th and 9th. Same fuse, with same amount of nitroglycerine in a *paper* case, was used. There was no explosion of the nitroglycerine.

10th. Same fuse, same amount of nitroglycerine in a *tin* case, was used. Nitroglycerine *detonated*.

11th. A copper-case fuse with mealed powder and same amount of nitroglycerine in a *paper* case was used. *Detonated*.

12th. A copper-case fuse with mealed powder and same amount of *dynamite* in a *paper* case was used. *Detonated*.

The following note was made at the time of the foregoing experiments: "From these experiments it would seem that nitroglycerine can be detonated by gunpowder if either the fuse case or the case holding the nitroglycerine is made of some metal and very strong. Thus it seems as if we could do away with the fulminate fuse, which is rather dangerous to make."

The result of these experiments gave a new impulse to a desire which I had long entertained of ascertaining whether or not shells filled with dynamite could be safely fired from great guns. Accordingly, on the 9th of June, 1874, I submitted to Captain (now Rear-Admiral) Edward Simpson, U. S. Navy, who commanded the

station, a list of experiments which I desired to make in order to ascertain the following facts: 1. Will the shock of a fulminate fuse detonate nitroglycerine, the latter being placed in an inner tube and the fuse between the inner and outer tube, both tubes being of iron? 2. Will a gunpowder instead of a fulminate fuse produce the same effect? 3. Will the shock transmitted through the metal case containing the nitroglycerine have any effect on the explosive, the tubes being arranged as before, but the one containing the explosive being of copper or tin? 4. Will the effect be the same when dynamite is substituted for nitroglycerine?

Should these experiments warrant me in so doing, then I desired to make the following experiments: 1. To fire from a musket or rifle a brass tube or metallic case filled with dynamite. 2. To put nitroglycerine or dynamite in an ordinary shell and explode it with an ordinary time fuse. Should this *not* explode the charge, (3) to try the same kind of fuse with an extra quantity of powder placed in the shell near the fuse. If this should detonate the charge in the shell, (4) to fire a shell filled with dynamite from a howitzer, firing it against a rock, if possible, so that, should the shock of the discharge fail to detonate the dynamite in the shell, it could be seen if the impact of the shell against the rock would do it. 5. To fire an ordinary shell filled with dynamite and fitted with ordinary service fuse. And (6) to try the same with percussion fuse. Captain Simpson took upon himself the responsibility and cheerfully granted the request.

I must here mention that Professor Hill, the expert on explosives, who was absent from the station on the 18th of May, while possibly willing to admit, in view of what had been done, that gunpowder fuses might at times detonate dynamite and nitroglycerine, insisted that they could not be relied on to do so at all times and under all circumstances. His opinion proved to be correct, as shown some months later, when it was attempted to detonate *unconfined* dynamite with a gunpowder fuse.

The following are the experiments as conducted, the fuses used being exploded by means of electricity, using the Farmer machine:—

EFFECT OF A FULMINATE-OF-MERCURY FUSE (20 GRAINS) ON NITROGLYCERINE IN A METALLIC TUBE PLACED INSIDE ANOTHER TUBE WITH FUSE BETWEEN.

June 15, 1874. No. 1. Inner tube made of one-inch iron gas pipe containing one ounce of nitroglycerine. Pipe plugged with

wood at one end. Outer tube of good iron, half inch in thickness. Fulminate-of-mercury fuse between. Top of inner tube not plugged. *Detonated*, throwing the whole mass a long distance into the water, and breaking the small rock on which the tubes were placed.

No. 2. Outer tube of one-inch iron gas pipe. Inner tube of brass one-sixteenth inch thick; length, one and a half inches; diameter over all, half inch, containing quarter ounce nitroglycerine. Fulminate-of-mercury fuse between. *Detonated.*

No. 3. To see the effect of an unconfined fulminate fuse on the metal of a tube. In a brass tube one-sixteenth inch thick, three inches long, three-quarters inch diameter, open at both ends, placed a fulminate-of-mercury fuse. Exploded, tearing the tube, although there was considerable space around the fuse and at the ends of the tube for the escape of gases.

No. 4. Same as No. 2, with same effect.

EFFECT OF GUNPOWDER FUSES.

June 16th. No. 5. In an ordinary iron gas-pipe tube, plugged tightly at one end, placed a small brass tube containing quarter ounce dynamite. Fired with mealed powder fuse, metallic case, which was jammed in between the two tubes. The fuse alone exploded, blowing out the inner tube.

No. 6. In a large iron tube, plugged at one end, placed a large brass tube one-eighth inch thick, six inches long, one and a half inches diameter, containing one ounce of dynamite. Cap screwed on one end and the other end soldered. Fuse of mealed powder, metallic case, jammed between the two tubes. Fuse alone exploded, forcing out the rear plug of the large outer tube about one inch.

No. 7. Used same large iron tube, inside of which placed a large brass tube, as before, containing one ounce of dynamite. Used DE_3 igniter (rifle powder and wood case) and filled outer tube with sand. Fuse alone exploded, throwing out the sand.

No. 8. In a brass tube three inches long, three-quarters inch diameter, put a half ounce of dynamite. Plug the ends and put this in the large iron tube. Put in DE_3 igniter and a charge of powder half as great as is contained in a DE_4 fuse, or from three to four charges for an ordinary musket. The igniter was placed between the tubes and the powder poured about it, while the remaining space was filled with sand. Exploded, driving out the rear plug and the sand, leaving the tube of dynamite uninjured inside.

No. 9. Used same inner tube, placed in an iron tube of ordinary one-inch gas pipe; space so small that with the insulated leading wires in the iron tube the inner one had to be forced down. Placed the same amount of powder as before in the outer tube at the base of the tube containing the dynamite. Fuse of mealed powder, metallic case. Fired at a rock a few feet distant. The end of the outer tube was torn, but the rock showed signs of having been struck. An end piece of the brass tube was picked up. The sound of the explosion was loud, but I could not tell whether the dynamite detonated or not: it certainly did not while in the iron tube, as the tube was not torn where the dynamite had been, but only where I had placed the large charge of powder. No sign of a great disturbance was discovered; still, judging from the result of the next experiment, it is possible that the dynamite may have detonated after having hit the rock, as a plug was protruding nearly three-quarters of an inch from the tube.

No. 10. Used same sized brass tube containing half ounce of dynamite. Put this in an iron gas-pipe tube six inches long and one inch in diameter. Used an ordinary charge of rifle powder and a DE_3 igniter. A wooden plug projected from a brass tube a good half inch. A board was placed four feet in front. Iron tube plugged at rear end. When fired much of the gas of the powder escaped at the rear, driving out the plug. The tube of dynamite entered the target one-fourth of an inch, and when picked up *was very hot*, with the hard oak plug driven entirely into the tube, a little counter-sunk, and *nitroglycerine was boiling out through the pores of the plug*. As the force exerted by the powder on the brass tube was not so great in this case as in No. 9, and as the target was a rock in the former case, I am inclined to the belief that the heat generated by impact may have detonated the mass in the preceding case (No. 9).

These experiments showed the necessity of having some kind of a gun, and of doing away with rough tubes and wooden plugs. Accordingly, a gun was made of wrought iron, calibre .75 inch, depth of bore 12 inches, thickness of barrel half inch; the whole firmly bolted to a block of wood. From this I fired projectiles consisting of brass tubes one-sixteenth inch thick, one and three-quarters inches long, and five-eighths inch in diameter. They contained a quarter ounce of dynamite.

June 18th. No. 11. Used small charge of rifle powder. Placed an inch board for a target at a distance of six feet. Tube passed through the board into the water.

No. 12. Same as No. 11, but with the ordinary charge of powder for a musket. Tube passed through the board and struck a rock in rear of the target. Picked up a piece of the tube. No detonation observed.

No. 13. Same as No 12, but with an increased charge of rifle powder. Target was blown down just before firing. Projectile went into the water. No detonation. Gun recoiled several feet.

No. 14. Charge of powder at least three times as great as for ordinary rifle. Tube went through the target and hit a rock, breaking off a small piece, then glanced into the water. Gun recoiled several feet.

June 19th. No. 15. Ordinary charge of powder. Fired at a rock. Tube much battered. No detonation.

No. 16. Ordinary charge of powder. Fired into a mud-bank three feet distant. Tube recovered in perfect shape, except that the soldered end came off.

No. 17. Double charge of powder. Target two and a half feet distant, set against a mud-bank. Projectile passed through the target, going into the mud-bank several inches. Found the tube torn, but the dynamite was picked up with the tube. Gun recoiled seven feet.

No. 18. Double charge of powder, tube of copper, containing one-eighth ounce dynamite. The tube passed through a board, struck a rock in the rear, then doubtless glanced into the water, as it could not be found.

No. 19. Same as No. 18. Fired through the target into the bank.

Experiments with 24-Pounder Shells at Rest.

These were exploded in the bomb-proofs on Rose Island.

June 22d. No. 20. Put four and a half ounces of dynamite into a 24-pounder shell. Used ordinary Bormann fuse, with an additional brass magazine containing a small rifle charge of powder. Placed in bomb-proof on Rose Island where there was much rubbish. Detonated, tearing the shell into many fragments, twenty-seven of which were picked up from the rubbish. Made a large hole in the ground.

June 25th. No. 21. In another bomb-proof, where there was not so much rubbish, exploded between three and four ounces of dynamite in a 24-pounder shell placed on a wrought-iron slab 4 feet by 5 inches by 1 inch. Used a small additional magazine of powder. Picked up fifty-eight pieces of shell and counted forty-nine marks on

the walls of the bomb-proof. The iron slab was somewhat bent, and the brick and stone under it were crumbled. A piece of the masonry running up the bomb-proof and projecting out eight inches, one foot in width, distant one and a half feet from the shell, was cut out a foot in depth.

No. 22. Put four ounces of dynamite in a 24-pounder shell, Bormann fuse, with no additional charge. Placed shell on same iron slab three inches from the wall. Detonated, bending slab. Tore quite a large hole in the solid masonry to a depth of six inches. Picked up seventy-nine pieces of shell.

No. 23. Put four ounces of dynamite in a 24-pounder shell, which was laid on fourteen bricks placed one on the other. Shell rested against an iron slab, which was itself against the wall, bringing the shell three feet from the ground. There being no fuse at hand for this shell, a small brass magazine was used. Slab was considerably bent by the explosion. The stone in the masonry against which the slab rested showed marks of having been shattered, but no large pieces came out. All the bricks underneath were broken into fragments. Fifty-six pieces of shell were picked up.

No. 24. Put three and a half ounces of dynamite in a 24-pounder shell, Bormann fuse only. Placed shell as in No. 23. Broke all the bricks upon which it rested. Bent slab, throwing it quite a distance, and jarred the masonry against which it was placed.

No. 25. Put three and a half ounces of dynamite in a 24-pounder shell, Bormann fuse only. Shell placed on a slab of iron, which was laid on the ground. Detonated with same effect as usual.

No. 26. Put what was left of the dynamite which I had taken to the island, about two ounces, in a 24-pounder shell, and used an old Bormann fuse the chamber of which had been cut into. The fuse alone went off. Probably part of the powder had shaken out of the chamber of the fuse, as it was a very old one and had been cut a long time. This and the very small quantity of dynamite in the shell—leaving so much room—were the causes, doubtless, of failure.

No. 27. In the same shell screwed a small brass magazine of powder. It *now* detonated, and threw the iron slab, weighing 80 pounds, which had been placed against the shell, thirteen feet and shattered corner of bomb-proof to some extent.

Experiments at Firing Dynamite Shells from a 24-Pound Howitzer.

June 30. A 24-pounder howitzer was transported from this station to Rose Island and mounted in one of the bomb-proofs. The cartridges used were the ordinary service charges, and the gun was fired in every respect as it would have been in service, except that the vent was filled with powder, which was ignited by electricity. *No measures were taken to reduce the shock of the discharge on the projectile in any of these trials.*

No. 28. From a 24-pounder, fired a shell nearly full of dynamite into a thick wall thirteen feet distant. The shell exploded on impact, making a hole in a solid rock seven inches in depth, which spread out considerably. The rock was pulverized. Picked up seventy-five pieces of shell.

July 2d. No. 29. Filled a 24-pounder shell loosely with dynamite and fired it into the wall of bômb-proof about forty feet distant. Detonated on impact, scooping out a hole in the brick, stone and mortar to the depth of ten inches.

No. 30. Then, to compare this effect with that of an empty shell, fired an empty 24-pounder shell into the wall at same distance. Penetrated fourteen and a half inches into wall, making a round hole instead of a spreading one. The shell broke, but half of it was taken out in one piece.

No. 31. Fired at same distance a 24-pounder shell loosely filled with dynamite. Detonated on impact, making a spreading hole like the first (No. 28), and penetrating about the same distance.

The following note was made at the time: "It seems from these (experiments) that dynamite detonates at the instant of impact, and so instantly that the shell does not penetrate as far as it would if it had no charge in it; but the shattering effect is greater."

Firing up the Bay.

July 8, 1874. Fired a 24-pounder shell filled with dynamite from bomb-proof on Rose Island. Pointed the gun up the Bay. Did not cut the fuse. The shell did not explode, but struck the water a mile distant (estimated).

No. 33. Fired a 24-pounder shell filled with dynamite, using Bormann fuse cut at four seconds. A half gale of wind was blowing in the direction of the flight of the shell. It was also cloudy. Several

disturbances were noticed in the water just beyond the island, probably pieces of sabot. The smoke attending the bursting of the Bormann fuse was so slight in amount it was not seen, owing to the peculiar state of the weather. The sound of the projectile through the air was heard for some time, as usual. Small pieces of shell striking the water in such a rough sea could not be seen at a great distance.

July 9th. No. 34. Fired a 24-pounder shell filled with dynamite, fuse purposely left uncut. Gun given almost extreme elevation. The shell went a long distance up the Bay and struck the water without exploding. Sea perfectly smooth ; no wind.

July 15th. No. 35. Put fourteen ounces of dynamite in a 24-pounder shell and fired it up the Bay. The Bormann fuse had been in the shell several days, and, though cut at four seconds, it did not burn. I had added a small magazine of powder, which did not ignite. The shell struck the water a long distance up the Bay without exploding.

No. 36. Put fourteen ounces of dynamite in a 24-pounder shell, Bormann fuse, with a very little extra powder, to show more clearly when the shell should burst. Fuse cut at four seconds. Shell burst at proper time.

No. 37. Put fourteen ounces of dynamite in a 24-pounder shell. Used Bormann fuse only, which was cut at three and a half seconds. Shell exploded at the proper time, scattering pieces to the right and left for a great distance. Not a grain of powder to help the fuse. The fuse made very little smoke.

Brief Recapitulation.

The first two and the fourth experiments were made to see what effect the shock of a fulminate-of-mercury fuse would have on nitroglycerine when separated from it by a diaphragm of metal. It was found that the fulminate fuse containing twenty grains would tear through the metal employed, hence all further experiments with the fulminate fuse ceased. The next series of experiments showed that in no case did the shock of a powder fuse, whether with a metallic or wooden case, detonate nitroglycerine when it was separated from the fuse by a metal diaphragm.

Again, in no case was there a premature explosion in all the experiments with the wrought-iron gun, although the best rifle powder was used with varying charges.

Again, in all the experiments made with the shells at rest, it was shown that the dynamite contained in them was exploded by the use of a gunpowder fuse, with or without an additional priming of powder, and the force of the explosions seemed to me to be much greater than it would have been had the shells been filled with powder instead of dynamite. I am sorry, however, that I did not explode one filled with powder, in order that the different effects of the explosions might have been compared at the time.

Again, the result of the howitzer experiments in firing shells charged with dynamite was very satisfactory. There were no premature explosions. Some of the fuses were left uncut on purpose, in order to observe the extreme flight of the shell. One shell was not seen to burst, neither was it seen to strike the water, but this is easily accounted for from the fact that dynamite makes little or no smoke when it detonates, and at the time referred to a half gale of wind was blowing, clouds obscured the sky, and the water was very rough. The flight of the shell was heard for a short time after it left the gun.

Having exhausted the available stock of shells at the Torpedo Station, experiments ceased, and on the very day of firing the last shell my detachment was received at the station. In a personal interview with the Chief of the Bureau of Ordnance soon after this, I urged that the experiments be continued on a larger scale, and asked that he would, at least, have a XV-inch shell filled with dynamite hung against an iron target and exploded. He gave some encouragement that this would be done, and a month later the late Commander Marvin, U. S. N., at that time, I think, in charge of the experimental battery, told me that it was to be done; but doubtless other things interfered.

These experiments were made in 1874. I then thought that this question was, perhaps, the most important one connected with ordnance; for we were far behind other nations in respect to ships and great guns, and should it have proved practicable to fire dynamite shells, our smooth-bore guns of large calibre could have been used, and at a bound we would have nearly regained our old position of superiority; for the armor of vessels was not so thick then as now, great guns were not so powerful, and machine guns had not reached their present state of development; but nothing further was done. Four years passed, and in 1878 I was again at the Torpedo Station, Captain K. R. Breese, U. S. Navy, commanding. Finding that my former experiments could not be continued, I requested permission to

pursue another branch of the subject, and addressed a communication to Captain Breese as follows:

TORPEDO STATION, NEWPORT, R. I., *June* 29, 1878.

Sir:—Can cases filled with nitroglycerine, dynamite, or gun-cotton be fired from great guns in safety to the guns and to those operating them? If either of them can be used in this manner, it seems to me the whole subject of torpedo warfare is immensely simplified.

To my mind the solution of this question is of more importance than that of any other connected with the subject of torpedoes. Four years ago I carried on a series of experiments at this station which, so far as they went, demonstrated that shell filled with dynamite—at least such dynamite as was then provided—could be fired from guns. My experiments were limited to the 24-pounder howitzer. The Chief of the Bureau of Ordnance did not see fit to encourage further experiments in that direction, and there the matter ended. That dynamite (or similar mixture) is regarded as comparatively harmless, is shown from the fact that it is transported by rail all over the country, and is used extensively in mining, etc. If the Whitehead and Harvey torpedoes are intended to be charged with gun-cotton or dynamite, these explosives will have to be carried in the ships from which these torpedoes are manipulated; hence, the objection cannot be raised by advocates of the Whitehead and Harvey that the danger of using these explosives on board ship is too great.

I now propose a plan which, if practicable, will enable us to use dynamite, nitroglycerine, or gun-cotton from the ordinary ship's launch, and I therefore respectfully request that I may make a few preliminary experiments with a 24-pounder howitzer.

I wish to see if I cannot throw a weight of from fifty to one hundred pounds a hundred feet or more without undue strain to the gun. If this can be done, I think torpedoes may be fired or projected against a vessel from an ordinary launch, and thus the difficulty of reaching a vessel protected by nettings, booms and other obstructions will be overcome. Not only this, but the launch could run at full speed past the broadside of the vessel and be out of harm's way by the time the torpedo exploded, for the gun could be trained broad off the bow, or even well-nigh abeam, when fired. I grant that the explosions might not always be at or below the water line, but let fifty pounds of dynamite explode against the vessel at night, it could not fail of demoralizing the crew, and a second attempt could be made before order was restored. I enclose with this a summary of my experiments made with dynamite, referred to above.

Very respectfully, etc., etc.

Captain Breese thought well of the idea and granted the request, although it interfered somewhat with the regular work at the station. And so soon as I had satisfied myself of the practicability of the scheme by actual practice, I reported it, in order that, should the Bureau of Ordnance see fit, the experiments could be carried on with the Bureau's approval and with greater facilities. At the suggestion

of Captain Breese I addressed the Bureau on the subject, and as an account of the experiments is contained in the letter, a copy is here inserted:

TORPEDO STATION, NEWPORT, R. I., *August* 8, 1878.

Commodore WM. JEFFERS,

Chief of Bureau of Ordnance, Washington, D. C.

Sir:—At the suggestion of Captain Breese, commanding this station, I beg to submit the following on the subject of torpedoes:

In July, 1874, I submitted to Commodore (then Captain) Simpson a report of some experiments made by me, in which from a 24-pounder howitzer I fired shells filled with dynamite. These experiments were undertaken to demonstrate that it would be safe to fire large shells or cases of dynamite, so that (I quote from the report) "wherever a large gun could be mounted, *there* would be a place from which torpedoes—for so we might call them—could be launched with great accuracy against an enemy, and much expense saved the Government by rendering unnecessary greatly extended fortifications and expensive torpedoes such as the 'Lay,' 'Whitehead,'" etc. This report was forwarded to the Bureau of Ordnance.

As there was no gun larger than a 24-pounder howitzer at the station, my experiments ceased after having fired successfully about a dozen shell. Last month, permission to make experiments of a somewhat similar character was kindly granted me. I wished to see if 12-pounder or 24-pounder howitzers could not be used to throw large charges of dynamite against vessels distant 50 to 200 yards, which charges should explode upon impact by means of percussion fuses. If this could be done, it would render useless as a defense against torpedoes of this class such obstructions as are now placed around vessels to protect them from the attack of torpedoes, for launches mounting one or more guns could run at full speed just outside the obstructions, and when abreast, or anywhere within 200 yards, these cases of dynamite or guncotton could be fired in quick succession without slowing the engines, or getting so near as to become entangled in the obstructions. To this end I made the following experiments:

July 12th. Made a soft-wood shaft to fit the bore of a 12-pounder. The shaft was grooved to within four inches of the inner end. It projected a few inches from the muzzle. On the outer end was secured an empty 24-pounder shell. The whole weight of the projectile was 30½ pounds. The charge of powder used was ½ pound cannon mixed with enough rice to preserve the original size and shape of the cartridge for the 12-pounder. Another reason for mixing rice with the powder was to make it burn more slowly. This projectile was sent as straight as an arrow to a distance of 450 feet.

SECOND EXPERIMENT.

July 15th. A new pine shaft was fitted to the bore as before, the inner end shod with iron $\frac{1}{16}$ inch in thickness. Secured an empty 32-pounder shell to the outer end. Total weight 43 pounds. Charge of powder the same as before (½ cannon mixed with rice). This projectile made a perfect line shot, being thrown from 100 to 150 yards.

Third Experiment.

Same as above with same result.

Fourth Experiment.

Fitted a shaft to a 24-pounder similar to the shaft used above. On the outer end an old cast-iron torpedo case filled with 41½ pounds of rice was secured. Whole weight of projectile, 99½ pounds. Extreme elevation on boat carriage. Much of the gas escaped on account of the imperfect construction of the shaft; nevertheless, this projectile was sent 50 yards, making a perfect line shot. Charge of powder used was one pound, mixed as before with rice.

These experiments, crude as they were, satisfied me that there would be no difficulty in throwing from 25 to 100 pounds of dynamite from 50 to 200 yards, using simply the ordinary boat howitzers.

There is much room for experiment to determine the best kind of powder to be used for this purpose, the proper charge, and the best kind of shaft, as well as the best form of case in which to place the explosive. There is no doubt but that the case should be made of steel.

In order to see what effect a charge of dynamite would have on a ship's side if exploded against it, the commandant of the station had a wrought-iron slab four and a half inches thick, three and a half feet wide and six and three-quarters feet long placed in position, and a cylindrical case containing 40 pounds of dynamite was placed against the centre of the slab.

The slab was bent by the effect of the explosion . . . . making a clear cut in the back of the slab to the depth of four inches, extending the whole width of the slab. The lumber placed in rear of the slab to support it was badly broken. My own impression is that for general use in steam launches, cases of 50 pounds of dynamite would be sufficiently great to give satisfactory results. The cylindrical case used in this experiment could have entered the bore of an VIII-inch gun. I believe that if a slow-burning powder were used, cases of dynamite could be fired a mile with great accuracy from great guns, the projectile being *set home against the cartridge* and thrown as a shell. In other words, the use of the wood shaft might be dispensed with when firing from great guns. It would be interesting to know what the effect of 50 pounds of dynamite would be if exploded on the deck of an ironclad. I respectfully submit the above to the Bureau, believing it to be a matter of the greatest importance, for it seems to me that torpedoes of this character, defying obstructions placed around vessels, might in the vast majority of cases be advantageously substituted for the awkward "spar," the cumbersome "Harvey" and the expensive "Lay," "Ericsson," and "Whitehead" torpedoes in offensive warfare. I have the honor to be, etc., etc., etc.

This communication was returned to the Torpedo Station with the following endorsement:

15th August, 1878.

Respectfully returned to the Torpedo Station. The Bureau has carefully perused the communication of the 8th inst. from Comdr. A. S. Barker. The

Navy is not prepared at present to carry dynamite to sea, and hitherto all experiments in firing dynamite shells from guns have been unsuccessful and useless. Upon a practically large scale, with projectiles carrying from 30 to 50 pounds, no useful results could be expected. Our funds will not admit at present of any such course of experiments. (Signed) W. N. JEFFERS,

Com. and Chief of Bureau.

Another four years pass, when I again have an opportunity to refer to the subject officially, in a communication to the Hon. Secretary of the Navy, dated Nov. 27, 1882, in obedience to an order to make a report upon the monitor Montauk, which I had commanded, and to offer suggestions for improvements. After having suggested a few changes—among others, that the guns be given an elevation of at least twelve degrees, by putting in improved gun-carriages, etc.—I continued substantially as follows:

In this connection I respectfully submit what I consider to be the most important change of all, and one which warrants careful attention—viz.: that in place of, or rather in addition to, the ordinary shell, there should be furnished projectiles of a peculiar kind filled with a violent explosive. They might be termed "torpedo shells," a name already used to designate certain projectiles thrown from Krupp's mortars. They should be made of steel, and for a XV-inch gun should have a capacity for at least 100 pounds of explosive.

Eight years ago, while at the Torpedo Station, with the approval of Commodore Simpson, commanding the station, I fired from a 24-pounder howitzer several shells filled with dynamite. The experiments, though limited in number, were successful, but the Chief of Bureau of Ordnance at that time did not think it advisable to have them continued on a larger scale.

Since that date Nobel's gelatine has been added to the list of explosives, and, from reports, it is admirably adapted for use in this manner. A XV-inch gun could throw a shell containing 100 pounds of gelatine a distance of two miles. Should the shell strike the solid armor of an ironclad, the explosive would probably detonate, but, whether it would or not, it would be easy to fit percussion and time fuses. Were the "monitors" thus supplied, foreign ships would scarcely care to venture within range of our guns, and beyond that range, provided an elevation of 12° could be obtained, they might fire at our turrets all day without making a satisfactory hit. The cross-section of these turrets is less than 25 feet by 12 feet, or but little larger than an ordinary target.

It is estimated by some English authorities that not more than one shot out of fifty hits a target in ordinary target practice at sea, and the usual distance of a target from a ship is much less than two miles. If, then, but one shot in fifty should hit the turret, the chances are that three-fourths of those hits would be glancing blows, owing to the curved surface of the turrets. All experience proves how difficult it is to hit a small object at sea when more than a mile distant. A few experiments, at comparatively small expense, would determine the practicability of using such shell, and also show the effect they would have against iron targets.

I am as thoroughly convinced that these projectiles will be used as I am that there will be future wars ; it is only a question of time. Already Krupp is dropping "torpedo shells" from his light mortars with great accuracy and effect, but in actual war they will be filled with gelatine or other explosive instead of powder. Why should not the United States be the first to make the change, if it prove practicable, and utilize her big smooth-bore guns ? It would not only greatly increase the efficiency of the "monitors," but also add to the importance of our coast fortifications.

That these were efficient vessels during the late war, hundreds of shot marks on turret and hull attest, and should the suggestions contained herein be adopted, I doubt not they will again be made efficient and formidable, and will be invaluable for the protection of our harbors against attacks by foreign navies. I am, Sir, etc., etc., etc.

Thus for twelve years, or since making the experiments in 1874, I have many times privately, and several times officially, referred to them and urged the importance of the subject.

I have frequently in this paper used the word "detonated" when referring to the explosion of dynamite and nitroglycerine. It has been questioned of late whether the effect of dynamite, if exploded with a gunpowder fuse, is ever as great as when a fulminate-of-mercury fuse is used—in other words, whether complete detonation actually takes place. It is further questioned whether dynamite or gun-cotton shells, bursting alongside an armored vessel, would materially injure her.

Doubtless the first question will soon be definitely settled by experiments at the Torpedo Station, and if it shall be proved that dynamite and gun-cotton shells will not be effective when exploded *alongside* an armored vessel, they must necessarily be effective when dropped *on* her decks from mortars. I myself am inclined to believe that the moral effect of high-explosive shells will always be great, and that they will also have a material effect on the vessel when exploded alongside.

My prediction in regard to the use of these shells is already being fulfilled, if the reports are true which come to us from abroad, and I am glad that our own Government is taking a deep interest in the subject. Congress has appropriated, or, it is said, will appropriate $350,000 for the construction of a pneumatic dynamite gun-vessel which shall carry guns guaranteed to throw projectiles containing one hundred pounds of dynamite, *or other high explosive*, a distance of at least one mile. Dare any one assert positively that our XV-inch guns cannot do even better than that?

U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

COMPRESSED GUN-COTTON FOR MILITARY PURPOSES, PARTICULARLY REGARDING ITS USE IN SHELL.

Experiments Made and Described by Max von Förster, First Lieutenant (Retired), Superintendent of the Gun-Cotton Factory of Wolff & Co., Walsrode, Germany.

TRANSLATED BY LIEUTENANT KARL ROHRER, U. S. N.

INTRODUCTION.

We have, in continuation of previously published researches, experimented further with compressed gun-cotton as to its development of strength, using greater quantities of the explosive and noting the effect of confinement thereon.

We have endeavored to carry on the experiments under circumstances such as would present themselves in military practice. With reference to military use of compressed gun-cotton, we have considered the advisability of paraffining it, also of coating by dipping it into a solvent solution of acetic ether. Finally, we made numerous experiments with gun-cotton-charged shell as to their explosive effect, and facility of firing them from existing ordnance, considering especially the adaptability of granulated gun-cotton for charging the same.

In the recently published work of Lieutenant-General Brialmont, "La Fortification du Temps Présent," Bruxelles, 1885, he refers particularly to the important effects of gun-cotton-charged shell, describing fully one charged with gun-cotton discs. This has encouraged us to hope that an account of our experiments may be of interest.

The experiments with gun-cotton shell made by us during several years past have been made entirely at our own expense and volition,

with the exception of those made by the artillery authorities of a foreign power with steel gun-cotton shell six calibres in length, in the presence of the author.

A portion of the results of our experiments has been made generally known through the following-named imperial German patents granted to us in common with Mr. W. F. Wolff:

No. 22,418.—Method of exploding wet compressed gun-cotton under water. September 1, 1882.

No. 24,674.—Explosive projectile charged with pressed gun-cotton. January 14, 1883. Treating of a shell with unscrewing head, filled with gun-cotton in disc form, provided with a detonator which is independent of the fuse and is located more toward the base of the shell.

No. 26,014.—Method of wholly or partially coating compressed gun-cotton, nitrated wood and other cellulose by means of treating same with a solvent solution. March 9, 1883.

No. 33,867.—Method of filling hollow projectiles with compressed granulated explosive material. May 2, 1885.

Our experiments, so far as regards the nature of the objects destroyed, could only be carried on within the confines of a gun-cotton factory, yet it is believed they will afford a standard of comparison for objects of all kinds.

We can, however, call attention to the explosive effects of compressed gun-cotton in submarine work by recounting the destruction of sunken vessels and wrecks accomplished by us for the Imperial Admiralty, the Imperial Navigation Bureau at Wilhelmshafen, other public authorities, and for private persons.

In our experiments we have used exclusively the gun-cotton manufactured at the powder and gun-cotton factory of Messrs. Wolff & Co., Walsrode. This gun-cotton is in use in the German Army, has also been tested and accepted for the German Navy, a large quantity having been taken into store. It is supplied to many armies and navies in and beyond Europe. So it may be said to fulfil all the conditions of a first-class article of gun-cotton, and therefore we may consider the results attained with it as equivalent to those to be attained by any good gun-cotton. If not otherwise stated, the specific gravity of this gun-cotton is 1.1, and it has an average of 12.6 per cent. of nitrogen by weight, in the absolutely dry gun-cotton and included foreign matter.

It is known that wet gun-cotton can be detonated by means of a

proportionate weight of dry gun-cotton, and we have so detonated it, whether special mention of the fact is made or not.

We detonated the dry gun-cotton by means of 1 gram fulminate-of-mercury detonators obtained from the Linden Primer Factory, Egestorf, Linden, near Hanover. These detonators retain their strength after a storage of five years, as we have so far found by experience.

Experiments with Regard to the Development of the Power of Compressed Gun-Cotton.

A.—*Unconfined Dry and Wet Gun-Cotton Placed upon Leaden Cylinders and Detonated.*

Experiments 1–4.—360 g. gun-cotton detonated upon a leaden cylinder 46 mm. diameter by 100 mm. high destroyed it; the dry gun-cotton half destroyed it, while the wet destroyed it entirely.

Experiment 5*a*.—6500 g. dry gun-cotton in discs 14 cm. diameter and a total height of 43 cm.

Experiment 5*b*.—6500 g. gun-cotton of same shape and dimensions and same dry weight, but with 25 per cent. of moisture.

In these two cases the gun-cotton was placed upon two blocks of rolled lead, each 15 cbcm. in volume, one above the other, and the two upon a perforated iron plate. The dry gun-cotton destroyed the upper leaden block, while the wet destroyed both.

Experiment 6.—A disc of dry gun-cotton 14 cm. diameter and 6 cm. high, weighing 920 g., provided with a detonator, was placed upon two leaden blocks as used in 5*a*, 5*b*, destroying them to about the same extent. It thus appears that an explosive charge of gun-cotton of 920 g. acts as powerfully on the object immediately under it as one of 6500 g., when the surfaces of the charges in contact with the object are equal. It may be that the detonator exercised an important influence in the development of the explosive force in this experiment; said influence will be more closely examined later.

In the continued experiments, the weight of the gun-cotton was so far reduced that the object upon which it was to develop its strength was not entirely destroyed; yet it was sufficiently great to produce craters in the leaden blocks with rims raised above the level of their upper surfaces, leaving the surface around the crater normal. To determine the comparative power developed, the rim of the crater

was cut through down to the level of the upper surface of the block, and by filling the crater to that level with water from a glass tube graduated in cubic cm., the amount of lead displaced was determined. The greater the number of cubic cm. of lead displaced, the greater the development of strength by the gun-cotton. The leaden blocks used were of sufficient size—15 cm. cubes—to admit the use of a considerable weight of gun-cotton.

Gun-cotton cartridges 38 mm. diameter, 50 mm. high, and weighing 63 g.:

Experiment 7.—1 dry cartridge displaced 27 cbcm. lead.

Experiment 8.—1 wet cartridge detonated by dry one above it displaced 36 cbcm. lead.

Experiment 9.—8 dry cartridges, one above the other, displaced 33.5 cbcm. lead.

Gun-cotton cartridges 60 m. diameter, 50 mm. high, and of different weights:

Experiment 10.—1 dry cartridge, 1.1 sp. gr., weighing 153 g., displaced 60 cbcm. lead.

Experiment 11.—1 dry cartridge, 1.28 sp. gr., weighing 178 g., displaced 90 cbcm. lead.

Experiment 12.—1 dry cartridge, 1.28 sp. gr., weighing 175 g., displaced 90 cbcm. lead.

Experiment 13.—1 cartridge as in 11 and 12, but containing 18 per cent. moisture, and hollowed out to receive a dry priming charge of 32 g., 1.1 sp. gr. The weight (dry) of gun-cotton same as in 11 and 12, and the cubic space same as 10, 11 and 12. Amount of lead displaced 148 cbcm., thus displacing 2½ times as much lead as in 10, and 1⅗ times as much as in 11 and 12.

Experiment 14.—Same as in 13, only the priming charge was 12.5 g.(?); so the whole cartridge had 12.5 g.(?) less gun-cotton in it; but the poorer result was not owing to this difference. Amount lead displaced 110 cbcm.

Experiment 15.—Cartridge as in 13 and 14; for priming charge there were used 8 discs, each 38 mm. diameter, placed one above the other, the detonator placed in the upper disc. Weight of each disc in priming charge 63 g. Amount of lead displaced 143 cbcm.

If, then, as has often been shown, the action of the last cartridge in long charges is reduced, in this case the eighth, it still fully served its purpose in developing the full power of the wet gun-cotton which it detonated.

Experiment 16.—3 cartridges, placed as before, each 60 mm. diameter, 50 mm. high, and of 1.1 sp. gr., weighing together 410 g., all dry, displaced lead 120 cbcm.

Experiment 17.—3 similar cartridges, but of 1.3 sp. gr., and weighing 488 g., displaced lead 200 cbcm.

Deductions.—Gun-cotton of a decidedly higher sp. gr. than 1.1 develops a materially greater power, and this increase is greater in proportion than the increase in the absolute weight of gun-cotton employed.

It is therefore generally advantageous for the development of power to employ gun-cotton of as high sp. gr. as possible, more especially in case the space for the reception of the charge is limited. However, the following experiments made with gun-cotton-charged-shell, and with charges not in contact with the objects to be destroyed, show that under circumstances different from the preceding the advantage of gun-cotton of a higher sp. gr. does not manifest itself so directly.

Effect of Gun-Cotton upon Objects not in Contact with it, but Separated by an Air-Space.

In order to secure a starting-point for comparison in the following experiments, the preliminary experiment (1) was made:

(1). A disc of gun-cotton 60 mm. diameter, 1.2 sp. gr., and weighing 181 g., was placed upon a piece of wrought iron 30 mm. thick and detonated.

The effect was to make a bowl-shaped indentation in the iron of the diameter of the gun-cotton disc and of 8 mm. depth in the centre. In addition to this, the effect on the under side of the iron was considerable: it was nearly broken through.

(2). A disc of gun-cotton 60 mm. diameter, 1.3 sp. gr., and weighing 181 g., was placed 34 mm. above a similar piece of iron to that used in (1) and detonated. It made an impression 55 mm. diameter and of a depth from 3 to 4 mm.

(3). A disc of gun-cotton 60 mm. diameter, 1.1 sp. gr., weighing 156 g., was placed exactly as in (2) and detonated. It made an impression 55 mm. diameter and of a depth from $1\frac{1}{2}$ to 2 mm. Moreover, in (2) and (3) the iron was separated lengthwise of the fibre, the crack running through to the under side.

The effect in general decreased, and in such way that the effect of (1) bore about the same relation to that of (2) which that of (2) bore to that of (3), and the differences of effect were considerable.

(4). A disc of gun-cotton, as in (2), of 1.3 sp. gr., was placed 100 mm. from the iron and detonated. Only traces of an impression were made.

(5). A disc of gun-cotton, as in (3), of 1.1 sp. gr., was placed 100 mm. from the iron and detonated. Traces of an impression were made, but fainter than in (4). The difference between effects in (4) and (5) was not very marked.

(6). Suspended in air 20 cm. from the trunk of a pine tree of 9 cm. diameter, and 35 cm. above the ground, was a charge of gun-cotton weighing 254 g. Upon the ground under the charge lay an oak plank 25 mm. thick. Upon detonation the bark was peeled off the pine tree, and a piece in the direction of its length was split from the plank.

(7). A charge of gun-cotton weighing 400 g. suspended in the same manner at 15 cm. from the trunk of the pine tree. Upon detonation the tree was cracked and another piece was split off the plank.

Deductions.—With an air-space between the gun-cotton and the object to be destroyed, the effect is very much reduced. With a greater air-space, the effect produced by gun-cotton of 1.1 sp. gr. does not differ materially from that produced when the sp. gr. is 1.3.

B.—*Explosive Experiments with Gun-Cotton Enclosed in Cast-Iron Shell.*

The gun-cotton was in the form of discs 139 mm. diameter and 50 mm. high, and of 1.1 sp. gr. The cavity in the shell was such as to receive these discs. The walls of the shell were 32 mm., the bottoms 60 mm., and the heads 120 mm. thick.

Two leaden blocks, 15 cbcm. in volume, resting upon a perforated iron plate, received the base of the shell. The upper block was always more or less destroyed. The effect could, however, be more accurately measured by the upsetting of the under block, and from the quantity of lead forced from its under side into the hole of the iron plate.

Experiment No. 1.—The shell was charged with 5200 g. dry gun-cotton, the detonator being placed at the greatest distance from the support—*i. e.*, in the uppermost disc.

Experiment No. 2.—The shell was charged with gun-cotton containing 20 per cent. of moisture; the same weight of dry gun-cotton, however, as in No. 1. The upper disc was dry, and served as a priming charge to detonate the wet ones.

Experiment No. 3.—The charge of the shell consisted of gun-cotton containing 20 per cent. of moisture; the discs were hollowed out in line with the axis of the shell to a diameter of 50 mm. In the head of the shell was a disc of dry gun-cotton as a priming charge to detonate the wet.

In analogy with the explosive effects of unconfined gun-cotton, it appeared evident that there would be a specially powerful effect produced down through open central channel upon the support.

Experiment No. 4.—The shell was charged with gun-cotton containing 20 per cent. of moisture, though the bottom disc, weighing 930 g., was dry, and in it was placed the detonator.

The effect in 3—hollow-charged—was least; then came 1, next 2, and in 4 the effect was greatest, the disc which was detonated by the detonator, and which then detonated the other discs, being almost in contact with the object to be acted upon.

In experimenting, it has manifested itself that gun-cotton detonated by a fulminate-of-mercury detonator acts more powerfully than when detonated by other gun-cotton. In this manifestation the immediate distance to which the detonation of the detonator acts plays a *rôle*. As soon as this distance is exceeded we conclude that the gun-cotton is no longer detonated by the detonator, but by other gun-cotton which it has detonated.

To investigate more closely the influence of the detonator upon the violence of the detonation, the following experiment was made:

Experiment No. 5.—Three 15 cbcm. leaden blocks were hollowed out in the middle to a diameter of 23 mm.; a fourth block of the same size was only half bored through. These four blocks were placed one on top of the other, the half-bored one on the bottom, and were secured in place with iron straps. The cavity down through the centre of the leaden blocks, being 52.5 cm. in length, was provided with a charge of gun-cotton 45 mm. long, made up of several discs 22.5 mm. in diameter, the lower disc resting on the bottom. The upper disc was bored out to receive the detonator, which last was connected to a string fuse which passed through a hole in a lead plug fitted into the cavity in the upper lead block.

After detonation it was found that the leaden blocks were each divided into four quite regular pieces; upon placing the pieces together again, it was seen that the detonation had increased the central hollow very materially—to 230 mm. diameter in the upper part, and to 130 mm. diameter in the lower part. The proportional spheres

would be about as 6 : 1, so that we must conclude that the part of the charge detonated by the detonator produced six times the effect which was produced by that part of the charge detonated by gun-cotton.

We infer from these experiments that it may be possible, by changing the physical characteristics of gun-cotton, or by a different manner of producing detonation of the same, to secure a considerably higher development of power.

The detonation of the detonator caused the gases from the detonated gun-cotton to be powerfully effective; but these powerful gases, acting upon the elastic gun-cotton, lose some of their force, and are not capable of developing gases of the same power from the remaining gun-cotton. So far, it has not been possible for us to continue the experiments within leaden blocks, so that we might have employed gun-cotton of 1.3 sp. gr., or perhaps nitroglycerine, which is not elastic; yet the experiments with unconfined charges afford ample ground for comparison.

Nor have we had the opportunity to try the effect of shell filled with gun-cotton of 1.3 sp. gr. upon objects of sufficient resistance to endure and show full amount of destructive work done, and upon objects generally.

The difference in effect between wet and dry gun-cotton manifested itself very slightly in the experiments made with shell, yet it is possible that this difference may exist to a considerable extent in confined charges, and that it may have only manifested itself upon the object confining it. The base of the shell was amply thick for the purpose. This relation could not be proven, as cast iron is a material which does not offer sufficient resistance to permit the different effects to be fully developed.

It is improbable that confinement, on all sides of equal strength, would exert any influence upon the development of power in compressed gun-cotton.

If a disc of compressed gun-cotton is detonated upon an armor-plate, or upon a sufficiently resisting piece of wrought iron, an exact impression of the face of the gun-cotton in contact will be left upon it, the dimensions of the impression being exactly those of the face of the gun-cotton in contact. The effect of the detonation only goes beyond this limit in that the immediately affected particles of the iron carry with them parts of those adjoining them. The gases generated by the detonation had, therefore, in the first instance, and as

long as they exerted their maximum force, the exact form and occupied the same space as was occupied by the gun-cotton before detonation. How suddenly the power is exerted is shown by the following experiment: If between a gun-cotton disc and the iron plate there be placed a coin, after detonation the raised figures and letters thereof will be left impressed in the iron. If, instead of a coin, a leaf is used, then after detonation the whole frame or skeleton of the leaf is left raised upon the iron. The larger as well as the smaller ribs of the leaf protected the underlying parts of the iron, while the thinner parts between could not yield such protection, and under them the impression is deeper.

C.—*Explosion of Shell upon Railway Rails.*

We exploded a number of shell upon such objects as in actual practice it would often be desired to destroy; and for charging them we employed granulated gun-cotton.

15 cm. cast-iron shell $2\frac{1}{2}$ calibres in length and of 2 litres charge capacity were filled with granulated gun-cotton. After charging, the shell were filled with melted paraffine, which will be more fully explained later. The dry as well as the wet grains of gun-cotton were coated by dipping in acetic ether. The explosive charges were:

Experiment No. 1.—Dry granulated gun-cotton 1200 g.

Experiment No. 2.—Gun-cotton with 25 per cent. moisture and 250 g. of dry.

Experiment No. 3.—Gun-cotton with 25 per cent. moisture and 150 g. of dry.

Experiment No. 4.—Gun-cotton with 25 per cent. moisture and 100 g. of dry.

Experiment No. 5.—Wholly paraffined gun-cotton and 300 g. dry, gelatinized.

Experiment No. 6.—Wholly paraffined gun-cotton and 200 g. dry, gelatinized.

Experiment No. 7.—Gun-cotton with 25 per cent. moisture and a priming charge 31 mm. diameter of 35 g.

Experiment No. 8.—Gun-cotton, dry, and a priming charge of 35 g.

Experiment No. 9.—Wholly paraffined gun-cotton, 150 g. dry gun-cotton, and a priming charge of 35 g.

Experiment No. 10.—Half a shell, divided lengthwise, filled with 1000 g. of gun-cotton in prisms (having a volume of 140 cbcm).

Experiment No. 11.—Two prisms as in 10, of 154 g. each, placed directly upon the base of a rail.

Experiment No. 12 —One such prism as in 11, laid upon a rail.

Each shell was provided with a priming charge 16 mm. diameter, weighing 9 g., for the reception of which a hole was left; in the priming charge was inserted the detonator of 1 g. fulminate of mercury.

The shell were placed upon a platform composed of three rails, bottom side up, the heads brought as close together as possible.

All the shell exploded perfectly. The effect was nearly the same in all. The rails were generally cut through, and where this did not happen an equal development of power was manifested in some other way.

No. 10 produced no greater effect than the others, which tends to show that granulated gun-cotton acts as powerfully as do compressed gun-cotton discs.

In 11 the rail was smoothly cut twice, in 12 once, the effect in comparison with the preceding being greater; which goes to show that confinement does not increase, but does perceptibly reduce, the effect upon the immediately underlying object; which is explained by the fact that the 20 mm. thick wall of the shell separated the gun-cotton from the rail. We note that we are speaking of the immediate and direct effect upon the underlying object. There is a general effect, which is exerted upon more distant objects, which must not be confounded with the former, and in which such short distances as 20 mm. need not be considered. This difference furnishes the reason why only relatively reliable results can be obtained in experiments where the effect can only be produced on one side and upon an object in immediate contact, and why our experiments, one time with the gun-cotton in immediate contact with the object, another time confined within an interposing object, did not furnish regular and well-defined results.

If, moreover, no more effect is produced upon the support by nine discs of gun-cotton than by one (see Experiment A, 5*a*, 5*b* and 6), it does not follow that in the former there is not more power developed proportionally to weight of gun-cotton. At all events, even with exclusive reference to effect, wet gun-cotton is preferable to dry, as where it is desired to destroy such objects as walls, arches, armor-plates, etc., with unconfined charges, care being taken to make contact surface between gun-cotton and object to be destroyed as great as possible.

Experiment No. 13.—A shell charged with granulated gun-cotton, wholly paraffined, provided with a priming charge 31 mm. diameter, weighing 65 g., placed in a cavity left therefor. Failed to detonate; portions of the charge burned.

Experiment No. 14.—A shell charged with granulated gun-cotton, wholly paraffined, provided with a priming charge 31 mm. diameter, weighing 100 g., was perfectly detonated.

In case a shell is charged with granulated gun-cotton and the charge is not cemented together, and to the shell, by means of melted paraffine, a much heavier and larger priming charge will be required to produce detonation.

Experiment No. 15.—A 21 cm. cast-iron shell charged with 4200 g. of dry granulated gun-cotton was placed upon a platform composed of a double layer of rails—five rails resting on their bottoms upon two wooden sills. On top of these were four rails, bottom up, in the interstices between the heads of the five bottom ones. The wooden sills were 1 m. apart.

The shell was covered to a depth of ½ m. with earth. The effect of the explosion was very marked. All the rails were cut through, most of them several times. In addition there was a hole made in the ground ½ m. deep. A bomb-proof cover would, in the light of this, be difficult of attainment.

D.—*Effect of Gun-Cotton and Gun-Cotton-Charged Shell in the Ground.*

Experiment No. 16.—A 15 cm. shell filled as before with granulated gun-cotton and buried 1 m. under ground produced in light earth, also in somewhat heavier earth, as loam and sand, a crater 60 cm. deep and 2 m. diameter.

Experiment No. 17.—A 15 cm. shell filled with 2100 g. ordinary cannon powder produced a crater 50 cm. deep, 2 m. long and 1½ m. wide.

Experiment No. 18.—A 15 cm. steel shell 6 calibres long, charged with 8.9 kg. granulated gun-cotton containing 25 per cent. of moisture, 1 kg. of dry grains, and a 35 g. priming charge, was so buried that its apex was 1 m. under ground, while its base was ¼ m. under. The crater produced was 1.3 m. deep and 4 m. diameter.

E.—*Experiments Comparing Effect Produced by Compressed Gun-Cotton Discs and Granulated Gun-Cotton.*

The ground in which the experiments were conducted is a light sandy loam.

Experiment No. 19.—A tin case 3 calibres long, of $7\frac{1}{2}$ l. capacity, filled with

$$\left.\begin{array}{l}\text{6300 g. wet granulated gun-cotton} \\ \text{300 g. dry ” ”}\end{array}\right\}\text{8 mm. cubes,}$$
50 g. priming charge,

5620 g. total weight of gun-cotton when dry,

was buried so that one end was 1.2 m. under ground, the other only .9 m. The crater produced was 1.1 m. deep and 3.3 m. diameter.

Experiment No. 20.—A charge of the same form as in 19, but consisting of wet gun-cotton discs of 8.3 kg. dry weight, and provided with a 50 g. priming charge, was buried as in 19. The crater produced was 1.3 m. deep and 4.1 m. diameter.

Experiment No. 21.—A tin case 6 calibres in length and of 15 l. capacity was filled with 11,150 g. of dry granulated gun-cotton (8 mm. cubes, gravimetric density .75) and provided with a priming charge of 50 g., then buried so that one end was 1.2 m. and the other was .6 m. under ground. The crater produced was 1.58 m. deep and 4.45 m. diameter.

Experiment No. 22.—A charge composed of wet gun-cotton discs of 16.6 kg. dry weight, and provided with a priming charge of 50 g., was buried as in 21. The crater produced was 1.56 m. deep and 5.1 m. diameter.

A piece of wrought iron 3 cm. thick and 10 cm. square was in the first two experiments placed directly in contact with and under one corner of the tin cases, and in the second two it was placed parallel to the sides of the cases and 15 cm. below, and the interval filled in with earth. In 19, 21 and 22 the piece of wrought iron was compressed to about the same degree, but in 20 the compression was perceptibly greater. In 19 and 20, the iron being in immediate contact with the cases containing the explosive, the discs of compressed gun-cotton proved more powerful in their action than the granulated gun-cotton.

Experiment No. 23.—A piece of railway rail .5 m. long, 12 cm. high, with 10 cm. base, was put upon two pieces of pine each 10 cm. square, placed 25 cm. apart, the whole set 1.25 m. below the surface. Earth was filled in 25 cm. above the top of the rail. A tin case, as in 19, filled with 5620 g. dry granulated gun-cotton and provided with a 10 g. priming charge, was laid over the middle of the rail and at right angles to it; then the hole was filled in to the original level. After explosion the rail was cut in three parts across its entire profile;

its base was pressed into the wood to a depth of 1 cm. The pieces of pine were not otherwise injured. The crater produced was 1.1 m. deep and 3.1 m. diameter. The pine pieces and fragments of rail were found 1.5 m. in the ground.

Experiment No. 24.—A charge of the same size as the tin case just used, composed of compressed gun-cotton discs of 8.3 kg. dry weight, and provided with a 50 g. priming charge, was located exactly as in 23.

The rail was cut to pieces almost in the same manner as before. There were only two pieces, however, out of which, towards the middle, a piece was broken from the upper surface in each. The base of the rail was not pressed into the pine supports, but they were cut in two straight across the middle. They evidently did not offer as much resistance as those used in 23. Beyond being cut in two they suffered no damage. The crater produced was 1.5 m. deep and 3.5 m. diameter, somewhat larger than in 23. The pieces of rail and wood were found 1.65 m. below the surface.

In both 23 and 24 the rail was cut, though placed 45 cm. below the charge. The bottoms of the craters produced were respectively 40 cm. and 80 cm. below the location of the charge. The pieces of rail and wood were forced into the ground to a depth of 90 cm., and at that depth the sandy earth was pulverized.

These experiments demonstrate that gun-cotton in either form produces powerful effects, not only in its immediate vicinity, but at appreciable distances.

It appears from these comparative experiments that, on the whole, the effect of equal volumes of granulated gun-cotton and compressed gun-cotton discs is about the same. The more than a third greater weight of gun-cotton in the compressed discs is scarcely realized in the general effect where a very considerable weight is employed and the object to be acted upon is not in immediate contact with the charge. Whether, with regard to other objects, and under other circumstances, the advantage of greater weight of gun-cotton in the use of the compressed discs, instead of granulated gun-cotton, will make itself felt, remains unsettled; but from the preceding experiments we are constrained to think it will do so in a very slight degree.

We are further of the opinion that it is very doubtful whether by the employment of specifically heavier or higher explosives than compressed gun-cotton, as explosive gelatine, a mixture of nitrate of benzol and aniline with nitric acid, or lower oxides of nitrogen, etc., in shell, a greater effect would be produced.

In actual practice the shell will seldom be in contact with the object to be destroyed by their explosive action; they will generally be somewhat removed, as, in firing against masonry or armor, they will not be in contact therewith their whole length—only slightly or not at all; and it is just at short distances from the object that the difference between a high and a lower explosive is realized.

In cast-iron shell with thick walls, the effect of the higher explosive would, perhaps, not be otherwise realized than in the pulverization of these walls, a result not generally desired.

In order to obtain a satisfactory basis of comparison of the development of power, and its effect upon objects from the different explosives, they should be experimented with under conditions of their probable use in actual practice.

We copy a few paragraphs from the work of Lieutenant-General Brialmont, already referred to:

"Ordinary 21 cm. steel shells charged with 14½ kg. of powder, fired from the Krupp rifled 21 cm. mortar at 45° elevation, forced themselves from 2 m. to 2.6 m. into the sandy earth of the firing ground at Meppen and produced elliptic craters 1.2 m. to 1.4 m. deep, 3.2 m. to 4.8 m. long, 3.2 m. to 4.0 m. wide. Fired at 28° and 60° elevation, less effect is produced.

"A steel torpedo shell 6 calibres in length, charged with 36 kg. of powder and fired at 35° elevation, produced a crater 1.0 m. to 2.2 m. deep, 3.2 m. to 5.0 m. long, 2.6 m. to 5.0 m. wide, which corresponds to a mean displacement of 7 cbm. of earth.

"In comparison with the foregoing, it appears that 21 cm. steel shell charged with gun-cotton force themselves 4 m. into the ground, there, lying nearly horizontally, produce craters 2.4 m. deep and 4.8 m. diameter, which corresponds to a mean displacement of 15 cbm. of earth.

"Arches made of the best concrete and 1.45 m. thick will be protected against the ordinary shell thrown from the 21 cm. rifled mortar by a covering of sandy earth 2.5 m. thick; against steel shell charged with 14½ kg. of powder by a similar covering 3 m. to 3.5 m. thick; and against torpedo shell charged with gun-cotton by a similar covering 5 m. thick.

"An earth-covering 5 m. thick will not be practicable, as fortifications would thus become too high, and the expense would be enormous. It is therefore suggested to leave off the earth-covering entirely and substitute a layer of granite or porphyry .8 m. thick, or a layer of Portland cement 1 m. to 1.2 m. thick.

"The experiments carried on in Silberberg in 1869 appear, however, to have demonstrated that perhaps this would not be sufficient protection even against the shell from the rifled mortar, when charged with powder only, as, since they made indentations ½ m. to ⅗ m. in depth, a second shell striking in the same spot would break through the arch."

Lieutenant-General Brialmont therefore believes that he cannot yet make a definite proposition; he suggests, however, that arches be made of the best concrete, 1 m. to 1.5 m. thick, and that they be covered with at least 3 m. of sandy earth. If this be not sufficient, then concrete must be substituted for part of the earth, or the depth of earth must be increased; or there must be added plate iron on the under side, which would appear to be the simplest and cheapest method.

The tendency appears to be toward the armored turret. We believe, however, that with large charges of gun-cotton even turrets can be effectively attacked.

Altogether, it appears that Lieutenant-General Brialmont regards the effect of gun-cotton shell, and their influence upon the future construction of fortifications, as of great importance.

Submarine Blasting with Compressed Gun-Cotton.

Blowing up the Tugboat Mathias Stinnes I, Sunk in the Rhine near the Railway Bridge of Rheinhausen, below Duisberg, by the Author and the Engineer Math. Rossenbeck.

The tug was a strong iron vessel built in the early days of such constructions, and was very solid in all its parts. Its stern was 200 m. from the railway bridge, which rests upon massive piers, and 100 m. from the right bank of the river, the hull pointing down stream and lying about parallel with the current. At average high water there were 2 m. depth above the deck aft, and 6 m. forward. The wreck was to be removed, so as to obtain a certain depth of water over it, to realize which it was necessary to entirely remove the after and midship portions. The current is so strong that it is impossible for a diver to descend without support against it.

A wooden barge was fitted with an iron shaft across its deck, on which, beyond the barge's side, an iron ladder was fitted to move freely in guides. When the ladder hung at the proper angle, it was held in place by a pulley, the lower part resting upon the wreck or some detached part of it, or upon the bottom, while the upper

part projected at least 2 m. above the shaft. To the ladder was attached an iron shield $\frac{2}{3}$ m. broad, which deflected the current. The ladder and its shield were raised and lowered by a pulley. The diver could reach the wreck by means of the ladder, and protected by the shield he could work, mostly with his left hand.

A second barge, of the largest kind, was decked over solidly and provided with a crane, by means of which and a chain the portions blown off were hoisted up.

Owing to the proximity of the railway bridge, and to avoid injuring it, great explosive charges could not be employed; nor would they have facilitated the work, but would have retarded it. No large charge, even one of 1000 kg. of the most powerful explosive, would have broken up the wreck in such a way as to make it possible to hoist up and get rid of the separate pieces. The explosion of such a charge would have produced a conglomeration of pieces of the wreck which, holding tenaciously together, could not have been hoisted up; nor would it have been possible then to finish the work with divers.

It became necessary, then, to blow off single parts by means of moderate charges, and hoist these up by means of barge and crane; so there were provided wooden boxes filled with 10 kg. of compressed gun-cotton, which were placed and exploded singly or in pairs.

The diver would descend by the ladder, place the charge advantageously, which, on account of the strong current, sometimes required hours to accomplish. He would come up, the ladder would be raised, the barge hauled out into the stream, and the charge exploded by electricity. The barge would be hauled back, the diver would descend and sling detached parts with the chain, an operation often consuming hours; then it would be attempted to raise them. Sometimes the attempt would be vain, as the apparently detached part was still connected with the wreck.

The plates were first raised, then the frames, the rudder, later the boilers, parts of the paddle-wheels, of the shaft, and of the engine. The shaft was of steel, 15 cm. diameter, and it was smoothly cut through several times with double charges of 20 kg. gun-cotton.

Powerful as is the effect of gun-cotton, yet there were over 100 explosions, consuming 1200 kg., necessary to remove the wreck to the desired depth. The after half was mostly raised; the other half was buried in the sand through violence of the explosions. The forward part, beyond the shaft, was very slightly worked upon, as it already lay under the desired depth of water.

It was again shown in this case that it is not possible to annihilate a vessel by explosion. Iron constructions cannot be made to disappear by explosion, unless they are raised and carried away afterward, or are forced under the bed of the stream thereby.

It is a different thing to sink a floating vessel. Explosive charges of 20 kg. gun-cotton, acting upon a suitable place on the outside of a ship and in immediate contact with it, will make a hole, but whether the damage will be great enough to sink her is doubtful. As to the effect when not in contact, we have observed that the explosion of 100 kg. of gun-cotton in deep water produces but a very slight effect on a floating object 100 m. distant; while the effect against rigid objects, as buildings, etc., of 100 kg. of gun-cotton exploded upon the ground will be felt at 500 to 800 m. distance.

Wrecks of wooden vessels are readily shattered to such an extent by explosion that the tide in ebbing and flooding, or other current, will carry away the pieces; and we have destroyed a number of such wrecks on the coast of the North Sea and in the mouths of the Jade and Weser. The charges were placed by divers against the sides of the vessel, where it was possible; otherwise they were lowered down upon it. They consisted of 100 kg. gun-cotton placed in rather long boxes. With small vessels two to three such charges well placed are sufficient, while with larger vessels a considerably greater number would be necessary.

Blasting in the Adlergrund.

In the Baltic, between Bornholm and Rügen, lies the Adlergrund, a shoal formed by bowlders resting on the bottom. The Royal Government had been deepening the shallowest places by hoisting up the bowlders by means of vessels provided with the necessary appliances. Divers descended and attached the chains or claws to the stones for raising them. In order to loosen the bowlders in their beds, and so facilitate the work, there were exploded numerous charges of 10 kg. gun-cotton in water from 4 to 6 m. deep. These explosions loosened each from two to four bowlders of about 2 cbm., forcing them well out of their beds.

Rock-Blasting in the Rhine to Deepen the Channel between Bingen and Coblenz.

In many places dangerous shoals exist in the Rhine, formed by rocks on the bottom; of these the Bingerloch is the most dangerous

and best known. To remove these shoals the rocks are drilled from floats and other vessels to a depth proportional to the height of stone to be removed; the holes are filled with powder and tamped with sand, and the charges are exploded. After 10 to 20 explosions, vessels provided with diving apparatus are hauled over the exploded ground, and the *débris* is hoisted up and disposed of.

It is our opinion that if high explosives were employed in this work instead of powder, the operations of removing the *débris*, which now are the most expensive part of the work, would be simplified and cheapened. It would not be necessary to drill the blast-holes so deep, as the detonation of a high explosive in them would shatter the rock from the beginning to the end of the hole; while, using powder, the lower third of the hole and surrounding rock remains, as a rule, intact. High explosives are not employed, because, in case of failure to explode, which will happen now and again, the explosive would remain in the rock, and might be accidentally exploded by the workmen while at work clearing away the *débris*, resulting in loss of life and property.

Using nitroglycerine preparations, this might readily occur, as these explosives are not made insensitive to detonation by concussion, no matter how long left in water. Using gun-cotton, however, as has been described by the author in a previous publication, the charges can be arranged in cartridges so that after a certain time, say 24 hours, the charge will certainly be saturated, and so become insensitive to explosion by concussion or by the detonation of the detonator.

Though advantages will be realized by the use of gun-cotton in this sort of work, yet it is our opinion that with its use, or that of any other high explosive, drilling will still have to be resorted to. In deep water, which may be regarded as tamping, high explosives simply placed upon the bottom and detonated do not accomplish enough work in the way of breaking up the surrounding rock, hence the cost of explosive necessary to accomplish the desired work would be too great. The only case we think of where it would be advantageous to blast without drilling is where a large surface of rock is to be removed to a very slight depth, 10 to 15 cm. Here the increased expense for explosive material would be provided for in the saving by not drilling or removing the *débris*, and the saving of time.

Paraffining Gun-Cotton.

(1). *Paraffining dry gun-cotton so that the paraffine permeates it entirely and occupies the place of water in wet gun-cotton.* Wet gun-cotton in store loses its moisture in time, unless it is hermetically sealed, and has to be dampened again. To save this labor, it has often been suggested to substitute paraffined for wet gun-cotton, because paraffine does not evaporate.

This suggestion would be very useful if paraffine were calculated to take the place of water in the premises. This is in nowise the case. Paraffined gun-cotton is a substance which lies between the wet and the dry, and has lost the best characteristics of both.

The chief advantage of gun-cotton containing 25 per cent. of moisture is its incombustibility. This peculiarity takes from it, for purposes of handling, storing and transportation, the character of an explosive, and it is a great advantage to be able to store it in this condition, where very large quantities are concerned. This is peculiarly realized in case of fire in the magazine or its vicinity; if the fire should burn a considerable time, owing to the presence of other combustible materials, the gun-cotton in store might be spoiled: danger can never arise.

So long as spontaneous decomposition cannot be considered absolutely impossible, will wet gun-cotton be preferable to all other explosives derived from nitrating organic substances, which are all inflammable, as with it there cannot occur spontaneous combustion. The characteristic of non-combustibility is what particularly recommends wet gun-cotton for military use, and makes it especially suitable for use in sea mines, as in this use circumstances combine to make it necessary to accumulate large quantities of explosive in one place. Such accumulation, in case of fire, is a great danger, as heat enough may be developed to produce an explosion.

Paraffined gun-cotton does not, however, possess the characteristic of non-combustibility, but is ignited by any and every little flame which may reach it, and, once ignited, it burns with the rapidity of dry gun-cotton. The rapidity with which fire spreads and develops in the explosive is the real measure of the danger which exists in a magazine filled with it.

For the further judgment of paraffined gun-cotton the following incident occurring at the factory in Walsrode may be cited: Pieces of gun-cotton only partially freed from acid were paraffined. After

two years it was found to be decomposing; green spots and cheesy places made their appearance; the whole mass became soft and fluid. In other words, the same phenomena were observed as in the decomposition of dry gun-cotton of poor quality. In a similar grade of wet gun-cotton this decomposition has not been observed.

Not only does paraffining not prevent decomposition, but it really encourages it, everything considered. Paraffined gun-cotton is produced from the wet by drying it and then dipping in a paraffine bath of 65° C. and leaving it therein until the paraffine has permeated all parts. It takes from ½ to 1 hour, according to the size of the piece. If the bath is cooler, then a longer time is required.

This process is always injurious to the gun-cotton, for it is certain that at the temperature of 65° C. nitrous acid is evolved, as may be shown by the iodide-starch-paper test. The acid so evolved is shut in by the paraffine, and cannot evaporate, as can the acid which time develops in wet and dry gun-cotton not hermetically sealed.

Experience in the factory at Walsrode has amply demonstrated, verified by the iodide-starch-paper test, that a not very stable article of gun-cotton which has opportunity to evaporate becomes more stable after a lapse of years. To be sure, the evolved acid will in part have been taken up by the chalk; the remainder will have disappeared, leaving the gun-cotton in a stabler condition. Slight traces of nitrous acid are developed in all gun-cotton, even at low temperatures. Digesting gun-cotton in warm, or sufficiently long in cold water, traces of nitrous acid will be noted in the water by the addition of sulphuric acid and iodide-zinc-starch solution. In this direction we made the following experiment: A sample of gun-cotton was washed until no trace of nitrous acid could be discovered in the wash-water. The sample was then placed in the drying cupboard for eight days and kept at the temperature of 30° C., again examined and traces of nitrous acid discovered. The same experiment repeated several times with the same sample invariably resulted in the same way. Wherefore we are constrained to believe that all gun-cotton contains nitrous acid.

But all potassium nitrate, as obtained in commerce and used for the manufacture of powder, contains nitrous acid. We applied to one of the most celebrated firms of chemical manufacturers for melted potassium nitrate free from it, and received as reply that they had not succeeded in producing such. Thereupon we attempted to produce it in our own laboratory by purifying with great care some that we

had on hand. After purification it was placed in a tightly closing gas flask. Upon examination after several months had passed, the saltpetre was found to again contain nitrous acid.

Professor Himly, of Kiel, expressed himself several times to the author to the effect that "all nitro-compounds are not stable, all organic substances decompose; for explosives only inorganic substances should be employed." True as this is in theory, practice does not warrant strict acceptance of the conclusion.

It will, however, even in the case of gun-cotton, be well to take every precaution in its manufacture; and later, in preparing it for explosive charges, too great reliance must not be placed in its safety, as is often done to the neglect of proper care.

We note, further, that when nitrous acid is evolved and combines with the chalk, forming calcium nitrate, it will not be injurious to the gun-cotton so long as not more acid is evolved than the chalk can absorb. In spite of this, however, acid reaction is obtained with the liquid iodide-starch or iodide-zinc-starch test, for the calcium nitrate is dissolved by the water used in digesting the gun-cotton; if sulphuric acid is added, free nitrous acid is liberated, and indicated by the reaction. Gun-cotton may in fact be acid-free, and yet upon investigation give nitrous-acid reaction. From all of which we infer that it is a vain effort to attempt to produce gun-cotton free from nitrous acid. The gun-cotton just discussed is, however, to be distinguished from such as still contains perceptible quantities of free acid, even nitric acid. In the case of the latter, it is our opinion that instead of improving with time, it will deteriorate and decompose. We have not discovered evidence that pulped and moderately acid-free gun-cotton will decompose by heat.

Returning to paraffined gun-cotton, we do not wish to be understood as having said that good gun-cotton would be decomposed to a dangerous degree by paraffining, but only that the process should be avoided when possible. Nor do we in general maintain that it is injurious to store good gun-cotton in hermetically sealed receptacles. We have, moreover, demonstrated that good gun-cotton so stored for years did not deteriorate, as proven by the iodide-starch test. We believe, however, that it will be better for all gun-cotton not to store it in hermetically sealed cases.

Turning to the physical characteristics of the paraffined gun-cotton, we find that its only similarity to the wet consists in being less sensitive to concussion than the dry, on account of which peculiarity

paraffining has been mainly recommended; it is, however, more sensitive to concussion, and to being ignited thereby, than gun-cotton containing 15 per cent. of moisture. To demonstrate this we made the following experiment:

Firing with the Mauser infantry rifle at short range at gun-cotton discs 15 cm. diameter and 5 cm. thick, those containing 15 per cent. of water withstood three hits, while the paraffined ones were ignited at the third hit.

The shocks which gun-cotton will have to withstand in its use in sea mines are readily withstood by it in the dry state; therefore it is not necessary to resort to paraffining on that account. The charges for fish torpedoes form an exception, in that they are frequently exposed to the enemy's fire, and for this very reason the use of paraffined gun-cotton would be unadvisable.

Now that it is demonstrated that paraffined gun-cotton is not sufficiently non-susceptible to concussion, it must also be acknowledged that it has lost its capacity for being detonated by 1 g. of fulminate of mercury, and that it can only be detonated by means of a priming charge of dry gun-cotton. Again, as paraffine does not evaporate, any gun-cotton which has been permeated with it cannot afterwards be utilized for priming charges; while, to use wet gun-cotton as such, it is only necessary to dry it.

We therefore reiterate our opinion that paraffined gun-cotton is not a good form of that explosive.

In the work of Manuel Eissler, Mining Engineer, New York, 1885, "The Modern High Explosives," great injustice is done to gun-cotton. He states that experiments in England have demonstrated that it is so sensitive to concussion that in a harbor defense of sea mines the whole defense could be neutralized by one countermine, which would, upon explosion, explode in succession all the mines of the system. As a matter of fact, there is no navy in Europe which does not almost exclusively employ this explosive for charging its sea mines, except where the old powder mines are still used, and principally because of its non-sensitiveness to concussion, as well as on account of its other favorable characteristics. And, also, in his descriptions of the chemical analyses and characteristics of gun-cotton, Mr. Eissler shows that he does not appreciate the nature and character of the explosive.

(2). *Paraffining dry gun-cotton so that the paraffine penetrates a few millimetres, and forms with the cotton penetrated an air and*

water-tight layer to protect the interior against moisture.—This practice suggests itself for the preparation of priming charges. The cavity for the detonator is closed by means of a piece of paper before dipping into the paraffine; after being thus treated these charges are protected against moisture for years. It is an improvement to coat the surface of the detonator cavity by applying acetic ether. Thus the priming charge is provided with a coating which will keep out moisture for a reasonable time after the paper cover has been broken through and the detonator inserted, even if placed in water. Sensitiveness to detonation is not decreased by this coat of dissolved gun-cotton, as it will detonate under water, and with water between the detonator and the surface of the cavity therefor.

For the priming charges of sea mines paraffining does not in any way recommend itself. However carefully it may be carried on, it is impossible to know whether the paraffine has penetrated just far enough or too far. There is always the possibility that the primer has been made unsusceptible to detonation by the detonator. Moreover, our observation goes to show that primers so prepared become cracked on the surface in time, thus opening themselves to the reception of moisture. A piece of gun-cotton is not a rigid object: it changes its form with change of temperature, and with change of moisture in the atmosphere.

These possibilities afford sufficient reason for the non-employment of paraffine in preparing primers for sea mines. It is better to protect them in store and in use by careful packing.

It should be further noted that air-dry primers will be detonated under all circumstances of season or weather by detonators containing 1 g. fulminate of mercury; so, if they be stored in dry and airy magazines, no fear need be entertained of failure to explode when good 1 g. detonators are used.

(3). *Paraffining Wet Gun-Cotton.*—Gun-cotton containing 25 per cent. of moisture may be penetrated several millimetres by paraffine, which, however, can go no farther, owing to the water within. The layer of paraffine remains perfect at medium temperatures, and affords a degree of protection against the evaporation of the moisture and against flaking. With considerable changes of temperature, as in freezing, numerous cracks form and the gun-cotton crumbles, thus neutralizing the two mentioned advantages. In the course of experiments made at the factory in Walsrode, it appeared that pieces of wet gun-cotton carefully paraffined might keep through one winter,

but not through two, without cracking. So many cracks formed that there was no more obstacle to the evaporation of the water nor to crumbling than in the case of similar wet, unparaffined cotton. Not unimportant is the fact that the paraffine layer enlarges the pieces, so that in a given space less gun-cotton can be placed. In pieces of 140 cbcm. the enlargement amounts to 12 per cent. Thus there is added to the gun-cotton an appreciable weight of a very combustible substance, which, with the wood of the packing cases, increases the danger in case of fire. Small pieces are not at all suitable for paraffining. If the paraffine layer is thinner than about 2 mm., then it does not serve its purpose for even a short time. Again, it is to be noted that it is uncommonly difficult and expensive to paraffine a large quantity of wet gun-cotton so that all the pieces shall be well covered, and, finally, that the sensitiveness to detonation is reduced.

It was experimentally shown that pieces of wet, paraffined gun-cotton could not be detonated by a 150 g. primer when they were not in immediate contact, though only 10 mm. apart. In unconfined charges, therefore, partial explosions and total failures might readily be realized.

The result is, that in view of the increased expense and other disadvantages, we cannot recommend the use of wet paraffined gun-cotton.

Coating Gun-Cotton by Immersing it in a Solvent Solution, as Acetic Ether.

This treatment has given very satisfactory results during the three years it has been exhaustively experimented with. The coating maintains itself well; cracking and flaking occur in a very slight degree. A lot of wet, coated gun-cotton was packed in a tightly closing box and stored, and another lot in an open box, and placed under water. Though cracks were developed here and there on a few of the pieces, yet the form and solidity given by the press were maintained. The time during which wet gun-cotton will retain its moisture depends materially upon the manner of packing. The coating is not impenetrable, but it does protect, to a considerable extent, against the reception of moisture in dry, and against its loss in wet, gun-cotton. The principal advantage of coating is its characteristic of making the pieces nearly as firm and tough as wood. This advantage will be appreciated by all who have noticed the condition of well-compressed

and packed gun-cotton after a long transportation. The coating is a protection against the formation of mould. If, however, the formation of mould is encouraged by the manner of packing and storing, and proceeds independently, as when it begins on the sides of the packing cases and gradually spreads over them and everything within, the pieces of gun-cotton will also be attacked, whether coated or not. If coated, however, the spores will not penetrate the coat, but remain on the exterior, and the mould may be washed or brushed off, and the structure and stability of the pieces will not be injured. It may be further noted that if wet gun-cotton upon which mould or other fungus is growing be placed in an airy place where it can dry, the growth of the fungus will be checked. It is also useful, when the cotton is in danger of injury from mould, caused by the climate or faulty packing and storage, to wet it with carbolic-acid solution.

Coating will recommend itself especially for gun-cotton to be used in fish torpedoes and sea mines, as it will have to withstand much transportation and handling and long storage. It will also be very useful in the case of cotton carried and used by troops in the field, and is absolutely necessary in the case of granulated gun-cotton for charging shells. In a shell so charged, upon being fired the charge will receive a violent shock, and be pulverized by the friction on the sides and base of the shell, and the powder may be ignited and so cause premature explosion. To avoid this, after charging the shell we pour in melted paraffine, which fills up the interstices, and upon cooling cements the grains to each other and the whole charge to the walls of the shell, making it a practically incompressible body, and prevents the upsetting of the charge or movement of any of its component parts. The coating on the individual grains prevents penetration of the melted paraffine, which is of great importance, as, if it penetrated, the sensitiveness to detonation would be so much reduced that priming charges would have to be increased to an extent that it would be difficult or impossible to insert them. All granulated gun-cotton is very much exposed to friction, and consequently to dusting, in handling, and only by coating does it become fit for transportation and war purposes. The sensitiveness to detonation is not at all reduced in coated gun-cotton, the dry remaining sensitive to the detonating action of the detonator, and the wet to the action of the dry. There is no reason why it should not be so, as in the process of coating there is no foreign matter added to the cotton. The acetic ether dissolves the cotton on the surface to the depth of the thickness

of a sheet of paper, and this dissolved cotton upon the evaporation of the ether remains as a thin, closely fitting skin. This skin is composed of dry gun-cotton, and it has, therefore, been truly said that coating by dipping in acetic ether makes wet gun-cotton combustible.

In the meantime, the word *ether* may encourage the idea that after the formation of the coating there may remain in it inflammable vapors of ether. This is, however, in nowise the case ; the ether of the solution evaporates rapidly, leaving behind the hard, dry skin alluded to.

The quantity of dry gun-cotton thus produced is very small indeed, amounting in a prism of 230 cbcm. to 1 g., and to less in one of 140 cbcm.—less than ½ per cent. A case containing 50 kg. wet, coated gun-cotton would also contain about ¼ kg. of dry, a quantity in itself no source of danger, and which, in comparison with the quantity of combustible material existing about all stores of wet gun-cotton, need not be taken into consideration. Gun-cotton is generally packed in wooden boxes pitched inside. The weight of wood for a 50 kg. box is 15 kg., the pitch ¼ kg. Ample combustible material is therefore on hand to produce sufficient heat in a magazine, in case of a serious fire, to evaporate all the water of the gun-cotton in it. The ½ per cent. of dry gun-cotton produced by coating would not change the relations, as it is not flying about in the form of dust to be ignited by any chance cause. As we have already intimated, we are of the opinion that keeping the gun-cotton wet precludes all danger in case of fire in a magazine, as it prevents a quick and violent development of it. We believe, however, that in all methods of packing so far practised, a fire in the magazine would result in great injury to the gun-cotton, or, if the fire-extinguishing apparatus were not very perfect and sufficient, in its total destruction. But in these premises coating would not influence the result. Coated gun-cotton retains the odor of the acetic ether for a long time. It disappears after a time, which indicates that all the ether has evaporated. A change in the gun-cotton or in the coating is not perceptible. We have also demonstrated that neither in the coating nor immediately under the same is there any acetic acid formed. If, however, in packing freshly coated gun-cotton there should be manifested traces of acetic acid, which might have been formed by the acetic-ether vapors mixing with atmospheric air, no harm would be done, as it can in nowise be injurious.

The practice of coating gun-cotton by dipping in acetic ether has been called "gelatinizing."

Gun-Cotton Shell.

It is admitted that the explosive effect of powder-charged shell against stone and iron arches, armored walls and turrets, is comparatively slight, and therefore great effort has been made to introduce shell charged with some high explosive. The most suitable explosive for the purpose appears to be compressed gun-cotton, for, while it is classed with the highest explosives, it is in a firm condition, easily handled, safe in transportation and storage, very slightly sensitive to concussion—not at all so in the wet state—chemically stable during long periods of storage, and it has been known and used with good results by military men for the last twenty years.

Starting from this point, it has been our object to make compressed gun-cotton the means of giving to shell a more powerful explosive effect. We have succeeded in finding a form of charge for shell, after extensive firing and exploding experiments, which appears to satisfy all demands, in that it not only admits of the firing of the shell from ordinary rifled ordnance, cannons or mortars without bore or premature explosions, but insures their explosion at the object. This charge, gun-cotton as well as fuse, will withstand the blow of the propelling powder gases, and there is no danger that either part of it will explode prematurely on account of such blow. We have demonstrated this by the following experiments:

(1). By firing a large number (over 200) of shell fully charged with gun-cotton from an 8.8 cm. cannon with 450 m. initial velocity. By firing from the 15 cm. rifled mortar with 200 m. initial velocity. By firing from a 15 cm. rifled cannon with 400 m, initial velocity. From the two last-mentioned pieces steel shells 6 calibres in length were also fired.

(2). By firing shell, out of which certain parts of the charge were left, against different targets, so that each part of the charge might be separately tested.

Besides the realized practical result that we fired these shells without any of them exploding in the bore, these experiments were made on the supposition that the shock of impact, at great final velocity, against a rigid object would be very much greater than that to be withstood in the bore by the action of the propelling powder gases against the shell. If the shell (from which the igniter has been removed, whose mission is to ignite the fuse on impact) withstands the former shock without exploding or even deforming any part of the explosive charge or fuse, it may with perfect safety be concluded that

it will under all circumstances withstand the latter shock; and, also, that when the igniter is added, premature explosions are not to be anticipated, as it is the same which has been used in the fuses heretofore employed and found safe. In addition to the igniter there is a detonator in connection with the fuse, which is necessary to detonate the gun-cotton. This detonator, which plays the most important part in experiments with gun-cotton shells, was differently constructed from the usual sort, and located in the charge with regard to the greatest safety, and was thoroughly tested, as the experiments show. In addition to the detonator described in our patent, we made use of another which satisfied all demands. After a combination of wet and dry gun-cotton is accepted as suitable for shell charges, the remainder of the problem is one of fuses, difficult, to be sure, but which we believe we have entirely solved.

The following are the experiments which are to demonstrate the power of resistance against shocks of our gun-cotton charges for shell:

(*a*). We fired loaded shell against rigid targets at short range, the igniters, which we regarded as out of the sphere of the experiments, were left out; otherwise the shell were completely charged and fused. The igniters were omitted because percussion fuses were used, which, in connection with them, would have been ignited upon impact and so have detonated the detonator. The shell struck with great final velocity, about 420 m.

The targets were earth-banks, hard-wood structures, and wooden structures covered with wrought-iron plates. We found that the shell withstood the shock of impact well, not detonating when the igniter was removed. We increased the strength of the wrought-iron plates on the target as far as the tenacity of the shell permitted, and found that so long as the empty shells fired against it did not break up, the loaded shells would also remain intact. When the shell breaks upon impact, the parts of the charge in their forward movement come into direct contact with the iron, and the friction sets fire to the gun-cotton and detonates the fuse. There were numerous cases in which the shell broke, lodging fragments in the earth-bank behind the target 1 m. deep, without there occurring burning or detonation of any part of the charge.

(*b*). We fired against the same targets shell charged only with gun-cotton, or only with the fuse and detonator—the igniter left out.

The former we afterwards opened by placing a gun-cotton car-

tridge upon them and detonating it, and if the charge of the shell was not detonated thereby or burned, it was shown that the individual grains were not bruised, and that the charge, as a whole, had not been set forward or backward by the shock of discharge or impact. The latter we filled with peas and a wet priming charge, and after firing they were opened by boring out the bottom, when it was shown that the detonator had not been detonated.

From the 8.8 cm. gun we fired shell of the ordinary form, but of steel, under the same conditions as above described, obtaining very good results; but before publishing them we desire to carry them further.

While the experiments with partially charged shell demonstrated that our sytem of gun-cotton shell charges is safe in firing, those with completely charged shell showed that the fuse arrangement functioned very well, and that the charge was always completely detonated. Partial explosions of the charge did not appear when using granulated gun-cotton. The form of gun-cotton which we prefer for charging shells differs materially from the ordinary disc form heretofore used.

A shell charged with gun-cotton in disc form is minutely described in Lieutenant-General Brialmont's "La Fortification du Temps Présent." The disc is not an advantageous form for gun-cotton to fill shell, as the projectile has to be made with movable head or base. We therefore also manufacture a granulated form, such that it can be put in the shell through the fuse-hole. Each grain has a sp. g. of over 1. The gravimetric density is .7. 700 g. (dry weight) fill a space of 1000 cbcm. The grains are rectangular, 8 to 12 mm. across, and either cubes or rectangles. They are gelatinized, thereby receiving a firm form and being protected against dusting. After the shell is charged with the grains, melted paraffine is poured in, which upon cooling cements them together and to the walls of the shell, forming a solid mass. For the larger shell, the principal part of the charge is composed of wet grains, to which are added about 200 g. dry grains, or enough to fill the shell. In using granulated nitrated cellulose for loading shells there will often occur partial explosions, burning or blowing away of part of the charge. Gun-cotton and other nitrated cellulose are more difficult to detonate than is generally supposed. We made the following experiments:

In a strong, tin-lined wooden box there was rammed wet uncompressed gun-cotton containing 30 per cent. of moisture, as hard as

could be without the aid of mechanical appliances; the box had $\frac{1}{4}$ cbm. capacity, and contained 50 pounds gun-cotton, dry weight. A piece of compressed gun-cotton weighing 500 g. was placed in the middle of this box and detonated, whereupon the box and its contents were torn to pieces and scattered in every direction, without causing even partial explosion or burning of the wet uncompressed cotton. A heap of similar cotton was laid on the ground, on top of which were placed 250 g. of compressed cotton and detonated. Again there was no explosion of the uncompressed cotton, though it could not escape the blow of the detonation.

Wet uncompressed gun-cotton is then to be considered as a non-explosive material. The transportation thereof in one of its lower orders, collodion-cotton, is permitted by the railways. There would be no danger to railway traffic if wet compressed gun-cotton were permitted to be transported under the same conditions as collodion-cotton, as, in relation to the incidents and accidents of transportation, it may be considered as collodion-cotton, while for use as an explosive it is much more advantageous. To carry this idea into practice it would be necessary to lower the prescribed percentage of moisture to 25 per cent. for compressed gun-cotton, instead of 50 per cent., as in collodion-cotton, as the former will not absorb 50 per cent. Gun-cotton containing 25 per cent. of moisture is an article which, under all circumstances of possible railway accidents, could not be exploded.

In store, at the point of utilization, the wet gun-cotton will become dry if not moistened when needful, and so become sensitive to detonation by a detonator.

If the transportation of wet compressed gun-cotton were free, it would be possible to supply to small consumers a high explosive. A material service would thus be rendered to rural economy, where a high explosive would be of great use in road-building and clearing land, as in blasting rock and breaking up stumps and roots.

Dry uncompressed gun-cotton burns fiercely, may explode, but does not detonate; it can be used as gunpowder. The conditions of granulated gun-cotton are similar. It naturally does not offer great resistance to the blow of the priming charge; nor is great resistance to be expected from part of a granulated charge against the action of another part which has been detonated by the priming charge. Gun-cotton is itself difficult to detonate if not in large, heavy pieces; it yields as it receives the blow of the priming charge, and is only

ignited or blown away. The finer the powder, the smaller and lighter the grains, the greater the inclination of the gun-cotton to burning or partial detonation, and therefore the priming charge must be large and the confinement great to realize complete detonation.

It is highly probable that it is not possible to detonate considerable quantities of most sorts of granulated nitrated cellulose in any practicable manner. With the granulated gun-cotton manufactured by us at Walsrode it is different. In the first place, the grains are not immoderately porous or light: they have the same composition as the larger masses of compressed gun-cotton. In the second place, the grains are not very small: 6 mm^3 is the minimum size; we preferably make them of the maximum size, 1 mm. thick by 25 mm. long, as it is easier to manufacture the larger sort. In the third place, the paraffine which we pour into the shell after charging it forms with the grains a compact mass, which acts as a piece of compressed gun-cotton. Generally a 1 g. fulminate-of-mercury detonator was sufficient to detonate this mass when the grains were dry; if they were wet or paraffined, then a proportionally large priming charge had to be provided.

While in the case of a shell charged with wet granulated gun-cotton, the charge cemented in the shell with paraffine, a priming charge of 35 g. is ample, it would be insufficient in the case of a similar charge wholly paraffined. In the latter case there would be required so large a priming charge that it would be difficult or impossible to find room for it. If a 65 g. priming charge is not sufficient to produce detonation, then will one of 100 g. be insufficient, though in the course of the experiments it once proved sufficient. On the contrary, there will result partial detonations and burning. Moreover, paraffining enlarges the grains and so reduces the gravimetric density of gun-cotton.

These reasons, combined with the loss of chemical stability in paraffined grains, seem to make their employment altogether inadvisable.

In the case of the wet and dry granulated gun-cotton made by us and united in one mass by paraffine, there is no danger of partial detonations. In case of slight confinement even, as in a light tin case, the gun-cotton is readily detonated, as the experiments show, and as follows from the nature of the case.

It is not possible to avoid a loss in weight of the explosive when

granulated instead of compressed gun-cotton is used, the sp. gr. being the same in each. Our experiments have shown, however, that the difference in destructive effect is not very marked. And in this connection it is in favor of the granulated gun-cotton that its shell, being in one piece, is stronger than the one made to be charged with compressed gun-cotton, which would have to be in two pieces. If not too great a demand is made on the strength of the shell, the sides of steel shell can be made thinner, and, in case of cast-iron ones, they may be lengthened, thus increasing the capacity for the explosive charge. Cast iron may still be considered as an acceptable material for shell in one piece. Thus may be secured a remarkably effective shell, yet a cheap one. Economy appears likely to become the only means of bringing gun-cotton shells to their greatest possible and, as it appears to us, necessary development, notwithstanding their always limited sphere of action. Granulated gun-cotton has the further advantage of furnishing a uniform explosive material for charging shell of all calibres and kinds. It is not necessary to enlarge upon the advantage this material has for the purpose over compressed gun-cotton, which would have to be provided of different sizes for different shell. The effort for uniformity in ammunition is well known, and shown to be necessary. Moreover, the use of this material will enable the whole stock on hand of cast-iron and steel shell to be converted into gun-cotton shell, thus not only securing for them a more powerful explosive effect, but also increasing greatly the number of fragments upon explosion, so that their effect must prove exceptionally great.

It is known that by casting a number of light bulkheads in the shell, and again by providing the shrapnel, the number of fragments realized from projectiles was greatly increased. The first method could only be applied to a limited class of shell, and so an increase of resulting fragments from shell generally is a great consideration. The second method has the disadvantage of creating a separate and peculiar kind of projectile, and it is admitted that shrapnel would be gladly dropped if an equivalent could be had in shell. The cast-iron shell charged with granulated gun-cotton is destined to realize great advantages in this direction, at least for use in fortification and siege artillery. It is hardly probable that gun-cotton shell will be introduced for field artillery.

The following experiments give an idea of the number of fragments to be realized from ordinary shell:

In a specially built compartment, walled in, well closed, lined with boards, and provided with an outlet for the gases, to moderate the effect of the most violent explosions, we exploded, and realized from an 8.8 cm. cast-iron shell weighing 7 kg. and charged with ordinary cannon powder 37 fragments, weighing altogether 6160 g. The same shell charged with granulated gun-cotton yielded 200 fragments each more than 10 g. heavy, and 600 fragments between 1 and 10 g. heavy. From an 8.8 cm. steel shell 6640 g. heavy and charged with granulated gun-cotton we realized 23 fragments of total weight 2260 g., and 127 fragments of total weight 2865 g., or 150 fragments of total weight 5125 g. From a cast-iron 15 cm. shell weighing 27 kg. and charged with ordinary cannon powder we realized 42 fragments. From the same shell charged with granulated gun-cotton we realized 376 fragments, each over 10 g. heavy, and 828 fragments, each from 1 to 10 g. heavy. A considerable part of a cast-iron shell is broken into minute fragments. In our examination we did not consider fragments of less than 1 g., though they deserve consideration, as most of them, through only the force derived from the explosion, were driven through boards 25 mm. thick; so that with them, in actual practice against troops, a considerable effect would be realized. Of fragments over 10 g.—which would receive velocity enough from the force of explosion to be effective at considerable distances—there were produced by the granulated gun-cotton charge nine times as many as by the powder charge; certainly an important result.

A peculiar characteristic of gun-cotton shell is, that unless provided with a retarded fuse they will explode upon impact, not an appreciable time after, as powder shell. In illustration of this we made the following experiments:

(*a*). Two targets ½ m. apart, and one behind the other, made of boards 40 mm. thick, were fired at with a gun-cotton shell, which went through the first, and exploded between the two.

(*b*). A target of boards 4 m. square was fired at with an 8.8 cm. cast-iron gun-cotton shell so that the shell struck the ground 2 m. in front of it. The shell exploded in front of the target, and the latter was penetrated by 135 fragments of the former.

(*c*). Two targets as in (*a*), but 2 m. apart, were fired at with an 8.8 cm. powder shell in such way that the centre of the target was struck. The shell went through both targets and exploded in an earth-bank beyond the second.

The powder shell was fused with the same percussion fuse as were the gun-cotton shells; the later explosion of the former cannot therefore be attributed to the fuse, as has heretofore been done, but must be due to the slower development of the powder gases as compared with the development of the gases from gun-cotton.

The characteristic of the gun-cotton shell, of exploding upon impact, must in many cases give it great advantage over the powder shell, as where objects are to be destroyed into which the shell cannot penetrate, as armor-plating or very strong masonry, struck at a small angle, from which the shell is deflected, and, if charged with powder, will be so late in exploding as to produce no effect; or again, in case of targets easily penetrated, when the powder shell will explode too late and beyond, as in trying to destroy ordnance stores and transportation trains.

By means of an interposed retardation in the fuse, through which detonation of the detonator is prevented upon impact, or by the use of a time fuse, the explosion of the gun-cotton shell may be regulated at pleasure. This retardation will be necessary in the bombarding of fortifications covered with earth, so that the latter may be penetrated before the shell explodes.

From the publications of the cast-steel works of F. Krupp in regard to their ordnance and firing experiments we copy the following paragraphs, as they appear to us to indicate where gun-cotton shell might be advantageously employed:

"Ordnance:—15cm. cannon 35 calibres in length.

"Projectiles:—

Kind of Projectile.	Length of Projectile.		Total weight in kg.	Weight of shell-charge in kg.
	Mm.	Calibre.		
Steel armor shell	500	3.35	51	1.5
Ordinary cast-iron shell	596	4	51	3.4
Ordinary cast-steel shell	670	4.5	51	6.2

"The mortar is intended for a different class of attack and defense than is the cannon, and the projectile therefor should be constructed with regard to this difference of object. In general the walls of a mortar shell may be made much thinner than those of cannon shell, as the gas pressures upon them in the bore are about in the ratio 1 : 2. The mortar is intended for firing at great elevations. Its objects are (1) to destroy earthworks; (2) to reach troops behind cover; (3) to break down cover.

"(1). For destroying earthworks, shell are necessary which have great penetration before explosion, take a large charge, and are strong enough to compel the complete conversion of powder into gas.

"It is necessary to fire at great elevations, and to use retarded percussion fuses. Cast-iron shell are not well adapted for this purpose, as they must have thick walls, consequently taking smaller charges; and again, they do not offer sufficient resistance to the developed gases, explosion resulting before all the powder of the filling charge is burned. Much more effective in this direction are steel shell, as they are free from the indicated faults.

"In case of firing with reduced charges, the thickness of wall of the steel shell may be very much reduced. To attain the normal weight it is then permissible to lengthen the shell. In this way shell with capacity for large explosive charges are obtained, and we have the so-called torpedo shell.

"(2). To reach troops behind cover, shrapnel is employed.

"(3). To break down cover. While for the destruction of earthworks it is necessary to retard the action of the percussion fuse, to secure great penetration before explosion, for breaking down cover it is desirable to secure explosion upon impact; otherwise the shell will explode on the rise after impact, causing the loss of the explosive effect on the cover. As is known, it has not yet been possible to remedy this fault, nor is it probable that it will be done, as even with the most sensitive fuses a certain time elapses from the impact to the explosion of the shell; and from the nature of the case this must occur so. It is necessary to strive for the shortening of this interval as much as possible."

From these extracts we perceive that the armor shell has capacity for only a small charge; and in the case of the larger calibres of steel armor shell, fired with brown powder at an initial velocity of 500 m. or more, an ever so powerful shell charge would not materially increase the effect of the projectile, though it would do so to some extent, as it would at least clear the hole made by it.

The cast-iron and cast-steel shell have capacity for explosive charges sufficiently large to produce marked effects.

The steel torpedo shell is the most suitable form of projectile for the employment of gun-cotton charges.

For the destruction of earthworks the gun-cotton shell is of great importance, as it produces greater effect in earth than the powder shell. Retarding the action of the fuse is easily attained.

For breaking down cover the gun-cotton shell is indispensable, as only it realizes the desired object of explosion upon impact, which can never be attained with the powder shell, as the slowness of its explosion is inherent in the powder, and not due to the fuse, as our experiments have shown.

The cast-iron shell will be much improved if charged with gun-cotton, for the comparatively weak confinement it affords to the explosive charge, and the reduction of the same on account of the great thickness of the walls, are more than counterbalanced by the quicker and stronger action of gun-cotton over powder. A steel shell with thin walls is always, however, preferable.

In regard to shrapnel, we note that it is probable that they may be wholly superseded by cast-iron gun-cotton shell, as our experiments have demonstrated that the latter yield as considerable a number of fragments upon explosion as do the former. We repeat that the common 15 cm. cast-iron shell, charged with gun-cotton, yielded upon explosion 376 fragments, each over 10 g. heavy, and 823 fragments, each between 1 and 10 g. heavy.

We hope that Mr. F. Krupp, with the great facilities which his establishment offers, will soon enter upon experiments with gun-cotton shell, as it is evident that they are at least calculated to supply a remedy for many important deficiencies in the effect of projectiles. If with a changed trajectory they offer advantages in the premises, as we saw in mentioning their characteristic of explosion upon impact, then is the question of a more powerful explosive than powder for charging shell of the greatest importance, though not of equal importance for all shell, and it must be decided in the near future. Should Mr. Krupp take hold of these experiments, we are convinced that he would carry them to a satisfactory conclusion in the brilliant manner in which he has so far solved all ordnance problems. If we could be of any assistance in the premises, with our gun-cotton factory, and with our experience of years in explosives, we would always be at his disposition.

Interesting paragraphs in regard to the employment of gun-cotton shell are found in Major Schumann's work upon armored turrets, and indeed he says: "In England there has been adopted for coast fortifications plating upon the so-called sandwich system, a combination of three to five plates of from 15 to 16 cm. thickness, with wood between.

"It may be expected that with the latest and materially improved

steel shell, penetration enough will be secured so that, charged with a high explosive, upon explosion a very destructive effect will be realized upon the whole system. The penetration of the projectiles in the massive rolled iron armor of 40 to 60 cm. thickness will naturally be much less. In case the plates are soft, and so not easily cracked, there may be expected considerable effect from shell charged with high explosive, and which strike at or near the edges of the plates. The two latest improvements in shell support each other here.

"The Krupp shell, made of the very best material, forged with a hammer upon a former, receive by this method of manufacture a degree of strength and toughness which enables them to withstand breaking up better than solid shot. Withal, the tempering is so perfect that, for example, a shell fired from a 15 cm. gun 35 calibres long went through two 18 cm. plates and 25 cm. of wood between them, and the only effect upon it was to grind the point down 1 mm.

"The second improvement consists in utilizing high explosives for charging shell whose hardness and toughness admit their penetrating far enough into soft, vertical rolled iron plates to at least make effective a part of the high-explosive charge. Where, then, such armor can be struck with sufficient velocity to give these shells necessary penetration to utilize the force of their high-explosive charges, it will be necessary to find means to obviate this penetration.

"Armored targets to be directly attacked are (*a*) armored ships, (*b*) armored coast fortifications, and (*c*) armored turrets occurring in the general system of fortifications of a country.

"The object of the Schumann system of construction is to protect the armored turrets of a general system of fortification against the direct fire of armor shell out of long guns. This is done by building the turrets in the form of an umbrella, upon which the shells cannot strike perpendicularly. They will strike at an acute angle and be deflected without having produced any effect. The explosive effect of the shell would be the only thing to do damage, but it will not act in time, as the shell will explode too late, whether charged with powder or gun-cotton."

From these deductions of Major Schumann, it appears that he expects to realize material results from the use of high explosives as charges for armor shell, and we take occasion to note what follows in relation to the technical construction of the shell:

If the shell which penetrates the armor is charged with gun-cot-

ton, and this is detonated by the shock of the shell against the armor, and indeed without the action of the priming charge and detonator—we do not doubt that the dry priming charge is ignited or exploded; the question is, whether it detonates so as to detonate the wet gun-cotton—then it will detonate before the shell has exerted its full force, or too early. The development of the gases from the detonation of gun-cotton, as compared with their development from the explosion of powder, is instantaneous, as we have observed and reported, and this will be so whether detonation results from the action of the detonator or the shock of impact.

A fuse, even a retarded one, in a shell which strikes armor at right angles and penetrates it will not withstand the shock—it will break up—and therefore no result can be expected in delaying the explosion through retardation of the fuse. If dry gun-cotton, therefore, is detonated by the shock of impact, then the shell will explode too soon; if, however, it does not detonate, but simply ignites, it would be possible, by disposing of the detonator in the shell in such a way that it will not be detonated by the shock of the powder gases against it in the bore, and thus cause premature explosion, to retard the explosion of the shell; and, indeed, the action within the shell would probably be as follows: The detonator would be detonated by the burning dry gun-cotton, and would detonate such portion of the dry gun-cotton as remained unconsumed. It will not occur that there is no dry gun-cotton left for the detonator to act on. By way of experiment, the above conditions may be realized by taking a piece of dry gun-cotton which has a hole in it to receive the detonator, placing one therein, and setting fire to the gun-cotton at some point and observing the result. In a great number of these experiments which we personally made, the gun-cotton was always detonated by the ignition and burning thereof, supplemented by the detonation of the detonator.

We have demonstrated that the same thing occurs in shell. We believe, further, that, suitably constructed and properly located, the detonator will be more difficult to detonate by shock than it is to ignite dry gun-cotton by the same means. Again, it is not to be feared that after the dry gun-cotton has begun to burn, the shell will explode before the detonator is detonated. It is consequently quite possible that an armor shell charged with wet and dry gun-cotton, and provided with a detonator, but no fuse, may explode at the right time, that is, not too soon, as the development of the flame in the

dry gun-cotton and carrying the same to the detonator consume a certain time. We are not aware that this has been demonstrated by experiment, but, on the other hand, it is quite evident that the circumstances will be much more favorable in the case of a shell which cannot, and should not, penetrate the armor. These shell will have the greatest possible explosive charge, and be provided with a fuse, naturally not a retarded one. Either the shell strikes the armor at an acute angle and is deflected, and it will upon striking, notwithstanding Major Schumann's opinion to the contrary, explode in a favorable position, being in contact with the armor its whole length, or it strikes at right angles, so that it breaks to pieces or is flattened. In either case it will explode at the right time to act with the whole explosive charge, as it will explode upon impact. We believe, therefore, that the Schumann armored constructions are not protected against the action of gun-cotton shell as they are against that of powder shell, and that gun-cotton shell will be of great service against armored constructions of all kinds.

The object of our experiments with gun-cotton shell has been to demonstrate that the ordinary shell may be converted into a gun-cotton shell very readily by means of an arrangement provided by us, and fired at great range from ordinary cannon, mortars and other ordnance, by means of the heretofore-employed powder; and to demonstrate the advantage thereof as compared with a proposed dynamite shell, to be propelled by compressed air from a peculiarly constructed gun, and as compared with many other proposed and some existing methods of throwing shell charged with high explosives; in all of which is necessary extraordinary apparatus, difficult of transportation, complicated in structure, and of great expense. We lay great stress upon the simplicity there is in the use of our gun-cotton shell, and feel in duty bound to express our opinion that, for throwing projectiles from guns, there should never be used anything but the compactest and cheapest power-developing agent, as gunpowder.

Our contrivances have reference only to the charging of heretofore ordinarily employed shell with gun-cotton. There is no change of material in any part, except in the explosive charge; even the weight of the gun-cotton-charged shell is the same as heretofore. These valuable results have been attained by us (1) through the manufacture of a new, peculiar, and suitable form of gun-cotton; (2) through a special arrangement in charging the shell, that is, filling them up

afterward with melted paraffine; (3) through constructing a suitable fuse.

We are convinced that gun-cotton shell will perform much important service, even if they do not work wonders.

The effect of high explosives is overrated; for example, upon a small area of armor no high explosive will produce nearly so much effect as will be produced by a steel shell from a 30 or 40 cm. cannon. However, there are but few such guns, and it is not possible to move them about to any extent. In field and siege operations the increase of effect through increase in calibre of gun soon reaches its limit; it is doubtful if there is any way to secure increased effect except by increasing the explosive effect of shell. We believe that shell charged with high explosives are to play a great part in the future, even though they do not accomplish as much as is unreasonably expected from them. For the very reason that they will not work wonders, it is our further opinion that the high explosives must be so adapted to them that they may be employed in the ordnance as it exists.

We give these lines to the kindly-disposed reader with the assurance that, while we have often spoken *pro domo*, yet it has been our effort to carry on the experiments impartially, and to draw the conclusions from them in the same spirit.

U. S. NAVAL INSTITUTE, NEWPORT BRANCH.

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NOTES ON THE LITERATURE OF EXPLOSIVES.*

BY CHARLES E. MUNROE.

No. XII.

In the *Phil. Mag.* **21,** 164–180; March, 1866, R. Threlfall published at length the results of his investigations "On the Theory of Explosions." † In his papers on the action of detonators, Sir Frederick Abel ‡ described some curious experiments, which he strove to account for by an hypothesis of "synchronous vibrations." § This hypothesis has been treated of at length by Berthelot, || and although much light, both experimental and theoretical, has been thrown on the matter by Vieille and Berthelot, the explanations offered by the latter do not seem altogether satisfactory to Mr. Threlfall, and he has concluded that something of interest might be gathered from a study of the behavior of the products of explosion, especially as regards the manner in which they escape from the centre at which the explosion takes place. Much might be learned from a measurement of the velocity of transmission of a shock to points at small distances from the centre of explosion. This would be merely a question of apparatus, and Lord Rayleigh suggested the use of a sensitive flame and revolving mirror, which would, at all events, give some idea of the sort of disturbance experienced; but Threlfall deemed it best to

* As it is proposed to continue these "Notes" from time to time, authors, publishers and manufacturers will do the writer a favor by sending him copies of their papers, publications or trade circulars.

† Proc. Nav. Inst. **12,** 197; 1886.

‡ Phil. Trans. **159,** 489; 1869.

§ Proc. Nav. Inst. **4,** 31; 1877.

|| Proc. Nav. Inst. **10,** 206; 1884.

begin by examining cases where the results of explosion could be seen and watched.

For this purpose he constructed a tank measuring a yard each way, and provided with windows in the sides. The tank was filled with water, and water-tight glass bulbs of ½ inch diameter, filled with mercuric fulminate, were sunk to a depth of 18 inches in the water, fired by electricity, and the course of the *débris* from the explosion noted. As the torpedo was suspended vertically, this *débris* had the appearance of being shot down to the bottom of the tank—not in a jet, as might have been expected, but with exactly the rolling motion that smoke has in coming out of a chimney—as if, in fact, there was vortex motion of some sort. The constancy of the downward action of the explosion suggested that it was due to the want of symmetry introduced by the neck and wires of the torpedo. Hence experiments were made in which the torpedoes were placed horizontally, and then the *débris* seemed to move, with its peculiar rolling motion, horizontally away from the neck. In fact, the appearance presented to the unaided eye was that of a more or less definite column of rolling white smoke shot out with great velocity, and coming to rest very rapidly when about five inches from the centre, as if acted upon by an irresistible force. Experiments were also made by exploding a charge in the centre of a Florence oil-flask filled with red dye and immersed in the water. The dye was shot out with the *débris*, and the flash appeared to be suddenly stopped some two or three inches outside where the flask would have been if it had not disappeared. There were, however, so many sources of misinterpretation to be feared in this method of observation that it was not continued, but the experimenter contented himself with noting the peculiar rolling and the dead-beat motion of the dye as it was shot out.

Experiments were now made to determine if the directions of projection of the *débris* coincided with the directions of propagation of the streams of explosive energy. For this purpose two forms of gauges were devised. The first consisted of a short, stout brass cylinder, closed at one end with a brass cap, and at the other by a diaphragm of thin sheet-rubber. To a hole in the side of the cylinder a smaller brass tube was fitted, and this was attached to a glass tube. The apparatus was then filled with colored water, and, of course, when held vertically, any pressure on the rubber caused the water in the gauge to rise in the tube. Two such gauges were made, and then were firmly fastened to the two adjacent sides of the tank,

the centres of the rubber faces being as nearly as possible in the same planes with the torpedo. Explosion caused these gauges to register, but they were not uniform in action, and were difficult to read, so they were abandoned for a gauge in which a piston moved in the horizontal brass cylinder, and the piston-rod abutted on the bob of a lever pendulum. To the other end of the pendulum a long, light index was attached. By firing some dozen torpedoes arranged as symmetrically as possible, he found that the indications of the latter gauges were nearly proportional. Explosions were then produced in torpedoes purposely made unsymmetrical, either by having the glass too thick on one side, or by turning up the ends of the covered conducting wires so that they entered the bulb horizontally and facing one of the gauges. The effects now became more puzzling, but on the whole there can be no question that the gauge towards which the bulb was turned suffered most. In fact, the direction taken by the streams of explosive energy appeared to coincide with the directions of projection of *débris*, and with the direction foretold from the initial conditions.

The experiments were repeated at various distances and in various manners with more or less compressed charges, and with variations in the position of the firing-point. The pendulum readings were on the whole certainly proportional to the direction of explosion as foretold from the initial conditions. Of course in some few cases there were unexpected actions on the gauges ; but this was hardly avoidable, since the previous experiments had shown how small a change in initial conditions could lead to great variations in the result. The position of the firing-point was the least satisfactory part of the experiments ; most of the failures could be traced to imperfect centring of the firing-point ; about ten per cent. of the experiments failed to travel on the paths laid out for them. These experiments leave little doubt that the direction in which the maximum explosive effect is transmitted will in a great measure depend on the initial arrangement of surrounding obstacles ;* at all events, when the explosion is caused by fulminate of mercury and small charges are used.

The shock of an explosion must be transmitted in one or more of three different ways :

I. By actual bodily motion of the products of explosion through the surrounding medium, either alone or becoming more and more mixed up with the medium itself, which is thereby set in motion.

* Proc. Nav. Inst. 9, 735 ; 1883.

II. By an undulatory motion set up in the medium.

III. By vortex-ring motion.

In the explosion of gunpowder and other slow explosives the energy is transmitted chiefly by I and II. The distance to which a considerable quantity of the energy may be conveyed by means of waves of comparatively great amplitude is in some cases remarkably great. This is evidenced by the effects produced by the explosion of powder magazines.

In the case of the fulminates of mercury and silver, gun-cotton and nitroglycerine—that is, explosives of the class examined under water—the effect falls off very rapidly with the distance, and in water, at all events, is of a directed character. This would point to the third mode of transmission being in these cases of some importance; and if we consider the way in which the products of explosion escape, we shall find that the conditions for the production of vortex motion do in fact exist. Let there be a sphere of fulminate of mercury fired from its geometrical centre. Then, by Vieille's* experiments on the time of explosion, it seems likely that the outer portions of fulminate will be decomposed before they are removed to any appreciable distance from their original positions. We shall therefore have a sudden expansion in all directions, caused by the increase in volume of the explosive substance during the explosion. There seems no reason, under perfectly symmetrical conditions, why the expansion should not go on as it began until the cooling of the sphere of hot gases becomes so marked as to prevent further expansion.

If the conditions, however, are not such as to allow of symmetrical expansion—as always occurs in practice—then we shall have the bounding surface of the explosion gases more curved in some places than in others; that is, the strain will be greater at some parts than at others, and in fact may become so great at points of great curvature as to lead to a state of "breakdown." In other words, the compressed gases will in this case escape, not by gradual expansion, but by jets, from points whose position is fixed by the conditions of explosion. In these jets we should have the necessary and sufficient conditions for the establishment of vortex motion. If vortex motion were set up, then it seems likely that much greater effects might be transmitted in some directions than in others, though at considerable distances the effects would tend to become uniform in all directions. The author believes that this view of the actions of explosions will enable

* Compt. Rend. 1882 and 1883.

us to explain several difficulties occurring in the interpretation of Abel's experiments. Among these are: The want of correspondence between the explosive actions, as measured by the effect produced on copper plates, and the effects produced in causing other explosions; the apparent capriciousness of explosions of the more violent kinds; the production of explosions by influence.

In his discussion of explosions, Berthelot has not added anything to the generally accepted theory that the explosion of gunpowder differs in no way from ordinary combustion, except that it is more rapid. His theory of detonation, however, is novel, and it may be summed up as follows: The kinetic energy of the shock of the explosion (by the detonator) is transformed into heat at the point struck; the temperature of this point is thus raised to the temperature of explosion; a new shock is produced which raises the temperature of the neighboring portions to the same degree; they then explode, and the action is thus propagated with an ever-increasing velocity.

Many experiments tend to show the justness of this view. To begin with, Abel found that almost any variety of effect could be obtained by burning explosives under diminished pressure. For, the lower the pressure, the more easily do the products of decomposition escape and carry with them the energy due to their liberation. By this means the temperature of explosion is constantly kept down, and the chemical character of the products modified in such a way that they correspond to the temperature. In other words, the compounds liberated are, as a rule, more complex than those which would be set free at a higher temperature, and therefore the energy run down is less.

Again, it will come to the same thing, so far as the propagation of an explosion is concerned, whether the products of decomposition are facilitated in their escape by conducting the experiment in a partial vacuum, or whether the decomposition is itself so slow that the products are enabled to escape without marked hindrance under ordinary pressure. Now, the resistance of the air to the escape of the products of combustion will depend on the rate at which they are liberated. And the shock given to neighboring portions of the explosive will be proportional to the pressure of the explosion gases at these points, and therefore ultimately to the resistance of the air, and hence to some function of the velocity of decomposition. But, in order to convert an explosion by combustion into an explosion by detonation, what is required is that the temperature of any point shall be raised

sufficiently to determine its complete, as distinguished from its incomplete, decomposition. The raising of the temperature of any point, however, will depend on the violence of the shock to which it is subjected; and this, as before stated, will be proportional to some function of the velocity of the decomposition producing it. If the necessary temperature is anywhere attained, we shall have detonation thereafter; if not, an explosion by combustion will result. It appears, therefore, that in order to produce a detonation, we require the initial velocity of decomposition to rise above a certain minimum value—that there is, in fact, a "critical velocity" of initial decomposition determining the kind of reaction which ultimately takes place. If the temperature of the whole mass be previously raised, then the critical velocity will become less. Berthelot considers that a specific change takes place in the stability of an explosive as its temperature is raised. This is doubtless true; but if a minimum temperature of any part be the necessary and sufficient condition for the production of a detonation, then the ease with which it can be obtained, when the mass starts with a high temperature, will, *cæteris paribus*, be greater than if the original temperature is low. If, therefore, we find that nitroglycerine is more liable to detonation the higher its initial temperature, we shall not be required to make any assumption as to "increased sensitiveness," since we see that the minimum temperature will be more easily reached, and that therefore the critical velocity of initial decomposition may be smaller. In other words, supposing we try to detonate nitroglycerine by an explosive which just fails at ordinary temperatures, we should expect its chances of success to increase as the temperature rises; and this does, in fact, occur.

The sensitiveness of an explosive to detonation has been found to depend on its state of aggregation. The critical velocity required to produce detonation will, *cæteris paribus*, depend on the nature and value of the elastic constants of the explosive, as well as of the medium in which it is to be exploded. We should, in fact, expect a change in the critical velocity of detonation if we exchanged the viscous resistance of liquid nitroglycerine for the elastic resistance of the same substance when frozen. Again, it seems possible, as a result of this theory, that less powerful detonation might be required to explode a given substance in water than in air; but the author is not aware of any experiments on this point. And so in other cases, though the critical velocity of detonation must necessarily be a very

complex function, and difficult to predict; yet there appears to be no reason on that account to minimize its importance. On the other hand, it seems to the author to be in complete harmony with Abel's experiments, and substantially embodies the views set forth by Dixon,* and the author knows of not a single experiment which offers any evidence against it. What is required by the theory for the production of a detonation is that a small part of the mass should be raised above a given temperature, and not that a large portion should be raised to a temperature below it.

This leads at once to the consideration of the second point—viz.: the action of detonators. The apparently anomalous effects discovered by Abel may be summed up by taking the most extreme case. Gun-cotton could be detonated by a charge of fulminate of mercury, whereas ten times as much nitroglycerine was required to cause a similar sample of gun-cotton to detonate. By firing the detonating charges on copper plates, Abel naturally observed that the destruction produced by the nitroglycerine was much the greater, and hence concluded that some other factor besides the "explosive violence" must come into play. This is undoubtedly true, but the mistake arises in looking at the experiments from one point of view alone—viz.: that of the copper plate. There will be no effect produced on the plate at all till the resistance of the air becomes greater than that of the plate; and this will never be the case, however great the volume of gas liberated, unless the time of explosion be sufficiently short. The resistance of the air varies at least as the square of the velocity of attack, and therefore this will be the conditioning factor of the destructive effect producible by explosions in free air. For a given increment of volume occurring in an explosion, till the time of explosion diminishes to a certain value depending on the strength of the plate, no effect will be observed; directly this limit is passed, the destructive effects will depend in the usual manner on the quantity of energy liberated. There is, in fact, a critical velocity of explosion below which the plate will not be attacked. But in a detonation the case is different. We do not require any great destructive effects: we only require that the time should be so short that a portion, no matter how small, of the substance to be detonated should be raised to the appropriate temperature. If the detonator has a time of explosion too great, then, although the air may be the stronger obstacle and the explosive destroyed, no detonation will be

* On Conditions of Chemical Change in Gases, *Phil. Trans.* 1884.

produced. This is precisely what happened in Abel's experiments, when the gun-cotton was blown to pieces by the nitroglycerine. The instantaneous rise of pressure is not so great for nitroglycerine as for fulminate of mercury, though the energy run down is much greater. This point has been satisfactorily proved by Vieille in his experiments with the crusher gauge. Moreover, the density of mercury fulminate is three times that of nitroglycerine, which allows a given mass to be on the whole much nearer its work if it consist of fulminate of mercury, than if it consist of nitroglycerine.

We ought not therefore to be surprised that the detonation of gun-cotton is easily accomplished by fulminate of mercury, and hardly accomplished by nitroglycerine. If there is any surprise, it would seem more fitting that it should be exhibited at the detonation which large charges of nitroglycerine seem able to effect.

This fact would tend to show merely that nitroglycerine has a velocity very near the critical point for gun-cotton—so much so, that when large charges are employed the acceleration in the explosion of the nitroglycerine is sufficient to pass the limit. We know from Dixon's work on gases that at first the explosion gains in velocity till the steady velocity of detonation is obtained, and there seems no reason against, but, on the other hand, every probability in favor of, the same thing taking place in nitroglycerine.

Above and beyond this, the difference in the mode of application of the two detonators must be taken into account. In Abel's experiment the fulminate was enclosed in a tube of copper or tin plate, while the nitroglycerine was merely applied in a capsule whose diameter was large compared with its depth. The upper end of the fulminate tube was probably closed by the electric firing-apparatus; and this, as was shown by the experiments in water already described, together with the fact that the fulminate was fired at the top, would give it an enormous advantage. For there is considerable probability that in explosions of high velocity in air, the final mode of "breakdown" of the gas liberated is very dependent on the initial conditions, just as it is shown to be in water. The nitroglycerine was deprived by Abel of these advantages; and for these and the reasons above mentioned, though it was able to blow blocks of compressed gun-cotton into powder, and even to cause some of this powder to penetrate the hard wood of the support, it failed to cause detonation.

The other apparently anomalous facts observed by Abel require further treatment, and most of all those explosions by influence, which

seem at first sight only explicable by some theory such as that of synchronous vibrations, suggested by Abel himself. The difference in the behavior of nitroglycerine and fulminate of mercury, regarded as detonators, led Abel to suggest that there might be some synchronism between the vibrations caused in air or ether by the latter explosive, and the natural period of vibration of a gun-cotton molecule. At all events, the supposition is made that fulminate of mercury when exploded can produce vibrations which are not produced by explosions of nitroglycerine, and that the superior detonating power of fulminate of mercury may be due to the presence of these vibrations. The first set of experiments bearing on this point have been already discussed, with the result that the hypothesis is perhaps unnecessary. There are, however, a great number of other experiments, some of which cannot be so easily explained. In one case an explosion was induced in a charge of fulminate of silver placed at the end of a tube by the explosion of a similar charge at the other end. The effect was not interfered with by placing diaphragms across the tube; but the state of the internal surface of the tube seemed to exercise considerable influence. Experiments were also made on the action of fulminate of mercury on gun-cotton* through tubes. The great influence exerted on the detonating power by the smoothness or roughness of the walls of the tube seems a strong argument against the supposed synchronism having much to do with the effect in these cases. On the other hand, it is just what we should expect if there was bodily motion down the tube, or even if, as in the case where diaphragms were inserted, the motion was transmitted from layer to layer without any great amount of displacement in each individual particle. It seems possible that some vortex motion caused by the "breakdown" might be transmitted through the tube, and that the diaphragms merely served to change the portions of air of which the rings were actually composed. The author admits that this is not very satisfactory; but if the roughening of the internal surface of the tubes actually exerted the effect attributed to it, we are justified, in the author's opinion, in supposing that the explosions were not caused by the transmission of vibrations through the material of the pipe itself. Again, vibrations, to be of any effect in producing chemical change, must be comparable as to period with the molecular vibrations. If such vibrations are transmitted through ether, it is difficult to see where

* Proc. Roy. Soc. **22**, 160; 1874.

the influence of chalking the inside of the tubes can come in; and if through air, their wave-length would be too small (as will be shown) to be likely to be much influenced by particles of the size of chalk-dust.

The similar experiments of Champion and Pellet* are sufficiently explained by their statement that they used iodide of nitrogen. Unless any one likes to suppose that the period of a fiddle-string may be comparable with the period of an iodide-of-nitrogen molecule, the further experiments of Champion and Pellet cannot be held to have much bearing on the subject. One can only wonder that they found a string that would vibrate slowly enough not to fire their iodide. As to their experiments with mirrors, blackened or otherwise, the results obtained might be anticipated on almost any theory except that of "synchronous vibrations." For the vibrations supposed on this theory to be most active would be precisely those absorbable by lampblack. This point has been investigated by Berthelot in a manner which leaves little doubt that he misunderstood Abel's theory. In order to show the importance of vibrations in producing chemical change, Berthelot experimented on various chemicals by swinging them on tuning-forks. No effect was produced, nor indeed was it to be expected, unless the reagents were of such a nature that they required intense shaking to keep them mixed. Berthelot also experimented on ozone at much higher frequencies of vibration by causing a tube filled with the gas, mixed with oxygen, to be set into violent longitudinal vibration. No change in the ordinary rate of decomposition of ozone was observed. This is very interesting, but does not seem to touch Abel's theory. In order to disprove the theory, Berthelot ought to have made his tube vibrate till it got luminous, and observed the effect on the ozone all the way up.

There are many well-established cases of torpedoes exploding one another by influence, and the same thing occurs in firing dynamite shots in mines. The former alone possesses any interest for our present purpose. If the effects due to fulminate of mercury when fired under water are in any way similar to those which may be supposed to take place on the detonation of large charges of gun-cotton, then, by the experiments described above, it would be likely that quite extraordinary effects might be propagated in some cases. There ought, however, to be a capriciousness in the observed action of torpedoes on one another; whether this has been observed or not, the author is

* Compt. Rend. 75, 110.

unable to state, but he assumes that it has not, and that here we have a case where the effect is largely due to "synchronous vibration." He therefore considers the ways in which vibrations of sufficiently small period could be transmitted, first assuming that no vibrations can have any influence unless they are of such period as to be comparable with the natural period of vibration of the molecules of the substance to be exploded.

Let a body be gradually heated, and its temperature measured as soon as light comes from it having the same refrangibility as the line A in the solar spectrum. Let the temperature be, say, of the order of 1500° C. Then the molecules of the body will be vibrating in some way comparable with the period of the A line; that is, about 4×10^{14} times per second. Suppose gun-cotton could be heated red hot without decomposition; then its molecular period would be of this order. We are quite unable to say how the period varies with the temperature in solid bodies at low temperatures. But the spectroscope shows that it does not change much at high temperatures.

The only possible way of obtaining an idea would be to extend the spectroscopic investigation even further than it has been done by Abney; either photographically or by the thermopile. We will assume, however, that as the bodies cool, their molecular vibrations, if altering at all as to period, tend to become slower, as well as of smaller amplitude. Let us consider the limiting condition of propagation of waves of longitudinal displacement. There seems no reason for supposing that the velocity of propagation would fall off till we come to waves of wave-length comparable with molecular distances—for instance with the mean free path. Now, by experiments in diffusion, it seems that the mean free path in oxygen is of the order of 5.6×10^{-6} cm.; in sugar solution it is 10^{-5} of this, or 5.6×10^{-11} cm.; while in solids it is probably much less. The size of the molecule, however, seems to be of the order 5.8×10^{-8} cm., so this will give our superior limit in solids and liquids.

Suppose that the smallest possible wave-length is the diameter of a molecule, and that the velocity of propagation is the same as that of sound down to this limit. Then, if V be the velocity of propagation, or the number of vibrations per second, and λ the wave-length in water, we have

$$n = \frac{V}{\lambda} = \frac{1.4 \times 10^5}{5.8 \times 10^{-8}} = 2.4 \times 10^{12}.$$

But it is unlikely that we could get a wave-length anything like so

small as this, so let us take as our limiting value the wave-length equal to a thousand molecular diameters. This gives us for the limiting frequency

$$n = 2.4 \times 10^9.$$

Comparing this with n for the A line, which is 4×10^{14}, we see that it is about a million times too slow to produce any effect on molecules vibrating so as to emit red light. But bodies at the ordinary temperature might possibly vibrate slowly enough to be influenced directly, though this is unlikely. It is rather surprising that the numbers are as comparable as they seem to be. If we perform the same operation for gases, putting $\lambda = 1000$ mean free paths, we get for oxygen $n = 5 \times 10^6$. Here the discrepancy is a thousand times as great; so that if longitudinal vibrations are to be considered as likely to produce any effect, they will be considerably more likely to do so if transmitted through solids or liquids than through gases.

We have still got the ether to fall back on, and there we are safe, for there is no reason why vibration of the right period should not be transmitted through it.

The experiments with tubes, however, seem to point exclusively to the air as the medium through which vibrations are to be transmitted, and that may be fairly regarded as unlikely. If the theory of synchronous vibrations can be disproved at all by experiment, then Abel has at all events made the most telling experiment against it; there may, of course, be other experiments, and these may point in the opposite dirction, but the author has failed to learn of them. Still, in the light of what has been published on the subject, there is little doubt that our natural hesitation to accept a theory of vibrations is justified by a consideration of the facts. On the other hand, if we admit that vortex motion may exist, it will account for some of the effects observed in the neighborhood of violent explosions. The most important effect to be accounted for is the capriciousness of explosions. Instances are so numerous that it is hardly worth while to dwell upon them in detail; but take the famous explosion at Bremerhaven, for instance, and it is curious to note the way in which the bystanders seemed actually singled out for injury, and that not always from flying *débris*. Such effects as these are difficult to account for on any theory of uniform propagation of wave-motion. On the other hand, any of the observed phenomena of propagation of explosion are as well explained by vortex propagation as by wave-motion. There is no reason why the two states of propagation should not exist together,

varying in their relative importance according as the explosion is of long or short duration. In ordinary cases of detonation, we may imagine the shocks to be given by the explosion gases before any considerable breakdown has taken place.

Raschig has studied the fulminating compound obtained by Berthelot nearly a hundred years ago by the action of ammonia upon silver oxide. For the preparation of the substance, a solution of silver nitrate was precipitated with sodium hydrate, and the silver oxide washed by decantation. For each grain of silver nitrate used, there were poured upon the silver oxide 2 cubic centimetres of an ammonia solution containing 25 per cent. of NH_3. The oxide of silver dissolved readily, leaving only a slight turbidity. The solution thus obtained was divided into several portions, each being placed in a porcelain dish about 10 cm. in diameter, so proportioned that no dish contained the oxide from more than one gram of the nitrate. Each dish was covered with a watch-glass and allowed to stand for 16 to 20 hours. The ammonia evaporated and the fulminating silver was deposited as a black, crystalline mass. After washing, it was analyzed by digestion with very dilute sulphuric acid, by which a residue of metallic silver was generally left. The dissolved silver was precipitated with hydrochloric acid, and in the filtrate the ammonia was determined as platino-chloride. The results of sixteen analyses gave ratios which were very close to three atoms of silver for one of nitrogen; leading to the formula NAg_3. Other samples of the substance, prepared by warming the ammonia solution of the silver oxide on the water bath, or by precipitating it with alcohol, gave the same ratio on analysis. It explodes by the slightest concussion when dry, and requires great caution in handling even when moist. It is soluble in ammonia and in potassium cyanide. (*Liebig's Ann.* **233**, 93–101, April, 1886; *Am. Jour. Sci.* (*abstr.*) **32** [3], 232, Sept., 1886.)

Isaac Friedenwald, Baltimore, Maryland, has published Part I of an "Index to the Literature of Explosives," prepared by Prof. Charles E. Munroe, U. S. N. A., which contains the titles of all papers relating to explosives or explosions which have appeared in *Am. Jour. Sci.* 1819–1886; *Phil. Trans. Roy. Soc.* 1665–1882; *Jour. Roy. U. S. Inst.* 1857–1885; *Proc. U. S. Nav. Inst.* 1874–1885; *Revue d'Artillerie*, 1871–1884; *H. M. Inspect. Explosives*, 1873–1885; making in all 442 separate publications. This index is intended to embrace not

only such articles as treat of the composition and of the chemical and physical properties of explosive substances, but also of their manufacture and use in the arts.

The *Army and Navy Gazette*, **27**, 801, October 9, 1886, gives the following glowing account of the new French mortar shell: It is stated that the French Budget Committee intend recommending £5,000,000 for new armaments, in consequence of the discovery of an explosive substance which necessitates serious changes. General Boulanger some time ago had his attention drawn to the fact that the Germans were manufacturing shells charged with *hellhofite*,* which had produced the most terrific effect on earthworks and masonry. Germany has already 175,000 of these shells in store. At the same time, the discovery of another explosive substance of equal if not of greater force than the German *hellhofite* was made in France (*mélinite*), the composition of which is kept a profound secret. At the first trial at Bourges, a gun charged with a *mélinite* shell burst, and caused fearful ravages. However, Lieutenant-Colonel Déjo, of the 3d Battalion of Fortress Artillery, has fired the new shell from a mortar, with similar results to those obtained in Germany. Neither walls nor earthworks nor plates can resist the force of this new agent. The shell is 40 inches long, about 8 inches in diameter, and weighs 220 pounds. General Boulanger got a deputation to accompany him to Soissons; one of the new shells was thrown into an old fort, and after explosion nothing of the fort remained. The committeemen were immediately convinced. One French writer, dwelling on the destructive quality of these shells, says that had they been used against Paris in 1870 by the Germans, or in 1871 against the Commune, the capital could not have resisted for a week. During the Commune, one house in the Avenue des Ternes was riddled by no fewer than 85 shells, and yet it did not fall. Now one of the new shells, we are assured, would destroy a whole block of houses. On the one hand, we are assured that *hellhofite* and *mélinite* have rendered all fortresses useless, and, on the other hand, we are informed that the profiles of all the new French forts are to be at once changed, so as to adapt them to the new order of things.

The *Jour. Mil. Service Inst.* **7**, 339–349, Sept., 1886, contains a rather rough translation by Major G. W. McKee, U. S. A., from the

* *Vide* Proc. Nav. Inst. **8**, 450; 1882, and **11**, 771; 1885.

Spanish of Adolfo Carrasco,* entitled "The Employment of Dynamite as a Bursting Charge for Artillery Projectiles." Mr. Carrasco details the composition and properties of dynamite, discusses its practical effects against armor, as shown by Folger's experiments, and considers its efficiency in projectiles, adopting the conditions set forth by us.† He then reviews the methods used and the results obtained in various experiments which have been made in firing projectiles charged with this agent, and after describing the dynamite air-gun and its use, he says: "Such an invention, neither by its arrangement, manipulation, nor effects, can be ranked as artillery, nor can we expect from its shots that which we do from projectiles charged with dynamite, as Lieutenant Zalinski has reported to his Government, and therefore it is useless to discuss it further here, what has been said sufficing to justify its exclusion." In connection with the Point-Lobos experiments, where the gun burst at the third round, he quotes Colonel Kelton as considering the results very satisfactory, since they had demonstrated the possibility of employing dynamite in shells. Much space is given to the experiments by the Snyder method, and this method seems to have made so favorable an impression upon Mr. Carrasco, that, in marking out a program of experiments for the purpose of verifying the results already obtained, and of proving the possibility or impossibility of the use of dynamite in projectiles, he seems to have decided to use the Snyder system in the firing trials.

It is interesting to read this *résumé* in connection with Commander Barker's account of his experiments in firing dynamite under service conditions, published in this number of our proceedings.

The Flood Rock explosion has naturally given rise to much literature on the subject, and among others we notice the paper by General John Newton, "The Improvement of East River and Hell Gate," *Popular Science Monthly*, **28**, 433–448, Feb., 1886; a note in the *Rivista di Artiglieria e Genio*, **I**, 160–170; 1886; an account of the blasting operations at Hell Gate, by L. F. Vernon-Harcourt, *Proc. Inst. Civil Eng.* **85**, 1–13; 1886; and another, "The Hell Gate Improvement," by Lieutenant George McC. Derby, U. S. A. (one of General Newton's assistants), in *Sanitary Engineer*, Dec. 3, 1885.

* Memorial de Artilleria, Nov., 1885.

† Van Nostrand's Eng. Mag. **32**, 3, Jan., 1885; Proc. Nav. Inst. **II**, 291; 1885.

This last is reprinted nearly in full in the *Illustrated Catalogue of the Rand Drill Company*, New York, 97–109; 1886. All of these are illustrated, the latter two especially so, as they show the methods of driving and charging and firing the mine, the nature and extent of the obstructions to be removed, and the appearance of the blast. The operations at Flood Rock are also noticed by M. G. Cerbelaud in his "Emploi de la Dynamite pour le Sautage des Grosses Mines," *Mem. Soc. Ingénieurs Civils*, 792–805, Dec., 1885.

We are indebted to General H. L. Abbot for six exquisite photographs of the Flood Rock explosion. Two of them were taken, one just before, the other just after the explosion, from a height of 260 feet above the water level. The other four were taken at the firing station, it being 1100 feet from the hoisting tower on Flood Rock. Of these, the first was taken just before the explosion, and the others at 0.2, 0.6 and 2.0 seconds respectively after the explosion. The first two views show that ignition by sympathy was transmitted so rapidly as to be practically instantaneous over the entire area of the rock, and that no failure occurred in any of the galleries. In a word, they demonstrate the entire success of this new mode of ignition. The height of the tallest jet was found to be about 160 feet. The charge of the mine is stated to have consisted of 240,399 pounds of rackarock and 48,537 pounds of dynamite No. 1.

We are indebted to General Abbot also for advanced sheets of his reports on the "Earth Wave at the Destruction of Flood Rock," and of his "Tests of Rackarock." In the first the data are given of the seismographic observations made at eight different stations, situated at distances of from about eight to one hundred and eighty-three miles from Flood Rock. From the discussion of these data the conclusions are reached that these observations indicate (1) an extraordinary velocity of wave-translation in both directions observed, which confirms General Abbot's deductions from the Hallet's Point and certain torpedo explosions,* that "the more violent the initial shock, the higher is the velocity of transmission." At Flood Rock the charge was about six times as large as at Hallet's Point, and the velocity was from two to three times as great over essentially the same route. (2). The uniformity of velocity to the northward, where the strata consist largely of homogeneous gneiss rock, and where the

* Am. Jour. Sci. **15** [3], 178; 1878.

velocity even for 175 miles exceeded 20,000 feet per second. (3). The varying velocity which appeared to characterize the wave moving to the eastward, through the drift formation of Long Island. Here there seems to have been a gradual increase of velocity, followed by a decrease as the wave advanced; but on the whole a decidedly less rapid rate is indicated than in traversing solid rock, as might be expected in media of varying density and elasticity. This result, although not inconsistent with the Hallet's Point observations, was not discovered from them, except as to the decrease in velocity as the wave disappeared. This is the only point where the four deductions from the earlier observations are modified by this later and more accurately observed explosion.

The Flood Rock explosion appears to have caused a continuous earth-tremor, which, observed under a magnifying power of about 18, lasted about one minute throughout the whole region covered by the observations, the maximum disturbance leading the advance, or nearly so, for at least fifty miles. At extreme ranges the tremor appears to have broken up into successive waves with well-marked intervals between them. These facts, the instantaneous nature of the explosion shown by the photographs, and the varying rates of advance through strata not homogeneous, appear to warrant the conclusion that the oscillation followed different routes to any given point—some near the surface and others at greater depths, where more dense and elastic strata produced changes in the direction of the wave-front and yielded higher velocities.

The whole subject is evidently too complex to warrant definite conclusions as to the velocity of ordinary earthquake waves, where the intensity of the original disturbance must always remain unknown.

The tests of rackarock showed that a mixture containing 21 per cent. of nitrobenzol (sp. gr. 1.33) was the most efficient; that it was important to have the potassium chlorate used perfectly dry; that the resulting intensity does not differ, whether the explosive is loosely or solidly compacted in the can; that an explosion of the first order is certainly obtained when the charge is fired by two service fuses, each containing 24 grains of fulminating mercury in a copper cap; that the mean pressure obtained in the experiments was 108 per cent. of that of dynamite No. 1; that the contractor supplied for Flood Rock an explosive of much higher intensity than was exacted by the terms of his contract.

Gen. Abbot concludes: "This high intensity, joined to the advantages of entire safety in transportation, exemption from all danger in case of accidental exudation of the fluid from loaded holes, and other practical merits discovered in charging the mine, in my judgment more than confirm the wisdom of your (Gen. Newton's) selection of this new explosive in preference to any form of dynamite for use in a work of this exceptional magnitude."

We are in receipt of a pamphlet from the Rendrock Powder Co., New York, which describes the method of preparing rackarock for use, and of adjusting the primers, and contains a report of an examination of rackarock by George G. André, M. E., etc. etc. In addition to the other advantages claimed for this substance, he asserts that the gases from its explosion are of a much less harmful character than those from gun-cotton or dynamite.

The success which has attended the use of rackarock, panclastite and hellhofite, has led Dr. Hermann Sprengel to seek to establish his claims to priority of invention. The result has been a series of articles in the *Chemical News*, **52**, 215, 271 and 295; 1885, and these have been gathered together, with extracts from various sources, and published by Dr. Sprengel under the title "The Hell-Gate Explosion and so-called Rackarock." From this we learn that while Dr. Sprengel invented his safety explosives in 1870, patented them in England April 6 and October 5, 1871, and published an account of them in August, 1873, Mr. Divine filed a caveat for his invention in the U. S. Patent Office January 9, 1871, though he did not patent it until December 7, 1880. To Dr. Sprengel, then, belongs the priority due to publication, and also the credit of being the first to recognize and point out the general principles which govern the manufacture and mode of action of this very numerous and very important class of explosives.

From the equations ordinarily found in our textbooks, it would appear that when potassium chlorate is heated it is resolved into potassium chloride and oxygen; but Frank L. Teed finds, in his researches on "The Decomposition of Potassium Chlorate by Heat," *Chem. News*, **52**, 248; 1885, that the reaction is by no means so simple, but that we have also potassium perchlorate, formed thus:

$$10KClO_3 = 6KClO_4 + 4KCl + 3O_2;$$

so that for every 74.5 parts of potassium chloride produced there should be 24 parts of oxygen evolved; also, that when the potassium chlorate shall have yielded 7.84 per cent. of oxygen, all the chlorate is decomposed and nothing but perchlorate and chloride remains. Any further oxygen evolved results from the decomposition of the perchlorate. When manganese binoxide is heated with the chlorate, no perchlorate is formed. Dr. Armstrong thought these results indicated a higher molecular weight for the salt than the formula used requires.

In the *Chem. News*, **53**, 145–147; 1886, E. J. Maumené, under the same title, calls attention to the fact that the reactions of potassium chlorate occupied his attention so long ago as 1845–46, his results being published in *Ann. de Chim.* **18**, 41, and that later he obtained similar results to those quoted above; but he makes the reaction still more complex.

Dr. H. Carrington Bolton finds that potassium or sodium peroxide may be readily prepared by heating the nitrate to fusion in a test tube until oxygen is freely evolved and then dropping in pellets of the metallic radical. The metal burns with a bright light and forms the peroxide, which dissolves in the molten mass.

On attempting to examine in the same way the action of sodium upon melted potassium chlorate a violent explosion occurred, projecting fragments of the test tube and the melted salt into the face and over the person of the operator. The explosion was instantaneous, and accompanied by a loud report. On repeating this with suitable precautions, using a stouter tube surrounded by a metallic cylinder, similar explosions resulted, without, however, breaking the glass. Pellets of sodium no larger than a grain of barley cause sharp reports the moment they reach the surface of the melted chlorate. (*Chem. News*, **58**, 289; 1886.)

In connection with the recent rapid advances made in the liquefaction of gases, the following statement of Faraday's, drawn from the *Jour. Sci. Roy. Inst.* **16**, 229–240; 1823, entitled "Historical Statement Respecting the Liquefaction of Gases," may prove interesting:

The *Phil. Trans.* for 1797, p. 222, contains an account of experiments made by Count Rumford to determine the force of fired gunpowder. Dissatisfied both with the deductions drawn and the means used previously, that philosopher proceeded to fire gunpowder in

cylinders of a known diameter and capacity, and closed by a valve loaded with a weight that could be varied at pleasure. By making the vessel strong enough and the weight sufficiently heavy, he succeeded in confining the products within the space previously occupied by the powder. The Count's object induced him to vary the quantity of gunpowder in different experiments, and to estimate the force exerted only at the moment of ignition, when it was at its maximum. This force, which he found to be prodigious, he attributes to aqueous vapor intensely heated, and makes no reference to the force of the gaseous bodies evolved. Without considering the phenomena which it is the Count's object to investigate, it may be remarked that in many experiments made by him, some of the gases, and especially carbonic-acid gas, were probably reduced to the liquid state. The Count says:

"When the force of the generated elastic vapor was sufficient to raise the weight, the explosion was attended by a very sharp and surprisingly loud report; but when the weight was not raised, as also when it was only a little moved, but not sufficiently to permit the leather stopper to be driven quite out of the bore, and the elastic fluid to make its escape, the report was scarcely audible at the distance of a few paces, and did not at all resemble the report which commonly attends the explosion of gunpowder. It was more like the noise which attends the breaking of a small glass tube than anything else to which it could be compared. In many of the experiments in which the elastic vapor was confined, this feeble report attending the explosion of the powder was immediately followed by another noise totally different from it, which appeared to be occasioned by the falling back of the weight upon the end of the barrel after it had been a little raised, but not sufficiently to permit the leather stopper to be driven quite out of the bore. In some of these experiments a very small part only of the generated elastic fluid made its escape. In these cases the report was of a peculiar kind, and, though perfectly audible at some considerable distance, yet not at all resembling the report of a musket. It was rather a very strong, sudden hissing, than a clear, distinct and sharp report."

In another place it is said: "What was very remarkable in all these experiments in which the generated elastic vapor was completely confined, was the small degree of expansive force which this vapor appeared to possess after it had been suffered to remain a few minutes, or even only a few seconds, confined in the barrel; for upon

raising the weight by means of its lever and suffering this vapor to escape, instead of escaping with a loud report, it rushed out with a hissing noise hardly so loud or so sharp as the report of a common air-gun, and its effects against the leather stopper, by which it assisted in raising the weight, were so feeble as not to be sensible." This the Count attributes to the formation of a hard mass like a stone within the cylinder, occasioned by the condensation of what was, at the moment of ignition, an elastic fluid. Such a substance was always found in these cases, but when the explosion raised the weight and blew out the stopper, nothing of this kind remained.

The effects here described, both of elastic force and its cessation on cooling, may evidently be referred as much to carbonic acid, and perhaps other gases, as to water. The sudden strong hissing observed as occurring when only a little of the products escaped, may have been due to the passage of the gases into the air with comparatively but little water, the circumstances being such as were not sufficient to confine the former, though they might the latter; for it cannot be doubted but that in similar circumstances the elastic force of carbonic acid would far surpass that of water. Count Rumford says that the gunpowder made use of, when well shaken together, occupied rather less space than an equal weight of water. The quantity of residuum before referred to, left by a given weight of gunpowder, is not mentioned, so that the actual space occupied by the vapor of water, carbonic acid, etc., at the moment of ignition, cannot be inferred. There can, however, be little doubt that when perfectly confined they were in the state of the substances in M. Cagniard de la Tour's experiments.

When allowed to remain a few minutes, or even seconds, the expansive force at first observed diminished exceedingly, so as scarcely to surpass that of the air in a charged air-gun. Of course, all that was due to the vaporization of water and some of the other products would cease as soon as the mass of the metal had absorbed the heat, and they would concrete into the hard substance found in the cylinder; but it does not seem too much to suppose that so much carbonic acid was generated in the combustion as would, if confined on the cooling of the apparatus, have been equal to many atmospheres, but that, being condensable, a part became liquid, and thus assisted in reducing the force within to what it was found to be.

The Pharmaceutical Record, **6**, 349–350; 1886, publishes a "Tabulated List of Explosive Substances," by Charles D. Lippincott,

which embraces such articles as are likely to explode when triturated singly or when mixed with other substances, and also of such as are liable to undergo spontaneous combustion. The list is prepared for the drug trade, and contains some curious information.

A recent publication, which may be found of value in connection with the study of gun-cotton, is issued in the form of a thin pamphlet by C. F. Cross and E. J. Bevan, and entitled "Cellulose." These authors have given much attention to the experimental study of this little-known but commonly-occurring body, the results having been published in the *Jour. Chem. Soc.* and elsewhere, and summarized here. The pamphlet has been written to impress upon the younger chemists the importance of further research in this rich but much neglected field of investigation.

U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

EXTRACT FROM THE REPORT OF THE MARCH TO WITU BY THE LANDING PARTY OF THE GERMAN CORVETTE GNEISENAU.

Translated from Supplement to Marineverordnungsblatt by
LIEUTENANT W. H. BEEHLER, U. S. N.

The Gneisenau arrived off Lamoo on the 28th of August, 1885, in obedience to the order of the Commander-in-Chief of the German East African Squadron, to obtain definite intelligence concerning the Witu district.

Commander von Prittnitz was sent in with three boats the next morning, in order to secure military command of the situation immediately. As soon as the boats crossed the bar, the Gneisenau proceeded to Manola and anchored close to the channel leading to Lamoo. Commander von Prittnitz was accompanied by Messrs. Denhardt and Küntzel as interpreters and guides for the march to Witu. At 4 P. M. Commander von Prittnitz returned on board with the report that the Bali of Lamoo was in command of the troops of the Said of Zanzibar at Kipini, on the Orzy River, with 1100 men, 450 of whom were regulars from the so-called guard stationed at Zanzibar.

This force had prepared an intrenched camp at 3000 metres from Witu, whence they intended to make their attack, when they received orders to return, without having committed any hostilities. An attack by the troops from Zanzibar had, however, not been feared in Witu, though they suffered considerably by the long, close blockade from the coast. Mr. Küntzel volunteered to remain in Lamoo to make preparations for the expedition.

The essential features of the march to Witu and return are related by Captain Valois as follows :

I left the ship at 5.30 A. M., August 31st, in the steam launch, with both cutters in tow, and proceeded up the channel to Lamoo, behind the island, around M'konumbi, from which point we commenced the

march to Witu. I detailed Lieutenant Gerstung to act as adjutant, Lieutenant Paschen as commander of the detachment, with Dr. Tereszkiewiez as assistant surgeon; two petty officers, twenty men, one musician, one hospital assistant, one commissary assistant, and the servants of the officers (being a total of thirty-three persons, officers and men). Eight days' rations were carried, and each man had sixty cartridges, while fifty rounds per man were carried as reserve in ammunition cases. The bearers brought by Mr. Küntzel from Zanzibar, and some pack animals from M'konumbi, were ready in the afternoon of August 30th.

As we passed Lamoo, at 7 o'clock in the morning, we met Mr. Denhardt, and continued our journey. At 11 A. M. we arrived at M'konumbi at low water, and immediately landed. I then decided to take up the march to Fungasombo immediately, in order to reach that place to bivouac for the night. The Seer of M'konumbi, who had been at Lamoo, came with Mr. Denhardt, and informed me that the Bali of Lamoo was aware of our intended march to Witu, and had issued orders that every assistance should be given us.

Mr. Küntzel had fifty-three bearers, two horses and three mules. The bearers were then detailed for the baggage, and at 1 P. M. we finally proceeded on our march to Fungasombo. The way led across a plain thickly covered with high grass, and the footpath was so narrow that the men were obliged to follow each other in single file. We arrived at Fungasombo at 4 P. M., having covered a distance of 8 sea-miles, measured by the piedometer. The pack was unladen and we encamped.

The march so far had not been difficult, as a light south wind freshened the air. Our arrival had been expected in the village, and a number of "kitandas" (sleeping-benches) and open straw mattresses were placed for us under some large mango trees. As the place was very small, we were obliged to bivouac. Only a few of the officers found shelter in a tent. Mosquitoes were so thick and pestiferous that it was impossible to get any sleep. The Seers and people of M'konumbi and Fungasombo were friendly and hospitable.

The march was resumed the next day, September 1st, at 6.30 A. M., after breakfast. The Pangani Lake was forded at 9 A. M. till 9.40 A. M. It was deemed unadvisable to make a *détour* of this lake, because too much time would have been lost. We rested in the shade of some bushes The men put on dry clothes and dined while the wet clothes were dried. The road to the lake led through grass

about six feet high, and obliged the men to march in single file. The ford through the lake was very narrow; the water reached half-way up the thigh, and the bottom was slimy and full of weeds, which made the forty minutes in the water very tiresome. This lake dries up entirely during the dry season, while in the wet season it is generally so deep that it can only be crossed by swimming.

At 1 P. M. we left the lake, and at 4 P. M. reached the Utesani forest, which we crossed in 20 minutes. We here met the first outposts of the Sultan of Witu, armed with guns, bows and arrows, who escorted us through the woods. We were expected at Witu, and when we passed through the forest we found ourselves in the Witu district, and arrived in the town at 6 P. M.

The distance covered from Fungasombo to Witu was about 4½ German miles. The path was over a gradually rising plain, but it was rough, and necessitated careful marching to prevent misstep. The greater portion was through tall, thick grass, which cut off every breath of air, and made the temperature, which was 86° F., much more oppressive. The mosquitoes infested the tall grass, and we were greatly annoyed, even in daytime. The country was apparently wooded, but in reality only had widely separated palm trees, which gave no shade whatever. The men overcame all these difficulties, with the exception of one man, who was obliged to have his comrades' assistance during the last stretch.

About 200 metres from the town we were met and welcomed by Sherif Abdallah, in the name of the Sultan. We were then conducted through the door of a palisade, and between the open ranks of the Sultan's warriors, to two houses which had been prepared for us. I then decided to have the interview with the Sultan the next morning.

The men had supper, and then retired to rest on the benches prepared for them in the dark rooms of the houses, where they were but little disturbed by the mosquitoes. There were but three slight cases of footsore men, but they did not impede the march.

The following details concerning Witu are from personal observations, together with information furnished by Messrs. Denhardt and Schlunke, Mr. Schlunke having lived in Witu for the past six months:

Witu has about 800 thatched-roof mud houses, generally without windows, and ventilated by the doors and the space between the walls and the projecting roof. All the houses are built of reed-work filled in with mud.

The house of Sultan Achmed is solidly built of smooth coral rock; it has a large carved door, but no windows, and it is kept scrupulously clean. A courtyard is enclosed by walls sufficient to contain a detachment of twenty-two men, in two companies, to serve as the guard against any attacks. On account of the blockade, which had lasted four months, they were deprived of many comforts, and for this reason the Sultan was not able to wait upon us with coffee and sherbet, as customary.

The site has an area of about 100 square yards, and is almost completely surrounded by a dense, impenetrable forest, and is only accessible through two palisaded gates with small doors, behind which a belt of the forest is cut away to make a street. Both gates are occupied by guards, on account of the proximity of the Arabs.

Near Witu there are two similarly fortified places, which serve to protect the exposed villages behind; at least they have never been captured by the Arabs, though during the last two and a half years new and more decided hostilities have been waged against Witu. At Witu there dwell from 2500 to 3000 men, though we found but 200 soldiers there, since the Sultan Achmed had sent the other 2000 men to their homes as soon as the Arabs withdrew.

The Sultan's soldiers are armed with flintlocks, percussion guns, bows and arrows, spears, and swords, some being detailed for guards at the gates and others for patrols. The men appear to be like the irregulars of Zanzibar, though somewhat more warlike, as might be supposed, from their arduous duty in holding such an advanced, exposed place as Witu. According to Messrs. Denhardt and Schlunke, the Sultan Achmed has 17,000 men under his command. This may appear to be an exaggeration, but the fact is that he has been able to hold this place against the most bitter enemies for twenty years.

In comparison with other East African places, Witu makes a favorable impression by its cleanliness and good regulations. The houses are not built compactly together, and many of them have small yards and gardens, with trees, etc. I did not see any dirty, lazy beggars, and I especially noticed the absence of all disagreeable odors.

The district is about 50 metres above the level of the sea, and the soil on both sides seems to be fruitful. A small tributary of the Osi would permit small, light-draught craft to approach to within one hour's walk in the dry season, and to within 1000 metres in the wet season. At this time we found sufficient water there for the men to bathe in, and in places up to their necks in depth.

The roads from Witu to the coast are mere footpaths, though there would be no difficulty in widening them. The ground is generally level and hard, except the marsh of Pangani, and several other places of very little extent. The paths are in this condition because it is customary for the caravans to proceed in single file instead of in pairs.

Between M'konumbi and Witu we did not meet the smallest tract of barren, sandy soil; every spot of ground was covered with grass and agricultural products. We found Indian corn, beans, olives and tobacco. The last is cultivated by the inhabitants for their own use, or for barter.

The land is rich in cattle. At M'konumbi there were 300 head of cattle, and I was astonished to learn that it is more difficult to raise cattle in the wet season than in the dry, because in the wet season the prevailing dampness causes a great deal of sickness. The crude manner in which young cattle are branded to mark their ownership must be a great cause of loss. I saw young calves scarcely able to stand with bloody foreheads made by cutting deep crossmarks, and others with deep rings cut out around their eyes.

Beyond Fungasombo all agriculture ceased up to beyond the Utesani forest; this was owing, doubtless, to the war.

At 9.30 A. M., September 2d, I went to call on the Sultan, accompanied by the officers, the German gentlemen and the detachment, and on the way passed through the drawn-up lines of his soldiers. After the Sultan had reviewed the sailors, and had shaken some of them by the hand, the detachment withdrew. It gave the Sultan a great deal of pleasure, subsequently, when I gave him a chromolithograph of the Emperor (full view, with Paris in the background). The interview was carried on by the adjutant, Lieutenant Gerstung, Lieutenant Paschen, Assistant Surgeon Tereszkiewiez, Messrs. Denhardt and Schlunke (the latter acting as interpreter), and by the Sultan's heir, Fumo Bakari, and several nobles of his kingdom.

In the afternoon the heir, Fumo Bakari, returned my call, and at the same time requested permission to send to Kipini to purchase supplies. In consequence of the blockade, cloth, oil, soap, petroleum, etc., were greatly in demand. By this mission it would be able to ascertain definitely if the Arabs intended to keep up hostilities, and I promised that in case any of his people should be held captive, I would intercede for their freedom in Lamoo, and also at Zanzibar.

The persons detailed to go to Kipini left early in the morning of

September 3d, and returned that evening, to the great joy of the entire community.

In the afternoon of September 3d I went with the officers and the German gentlemen to bid farewell to the Sultan, and at the same time presented him with some clothes and a roll of blue cloth, after I had presented the heir with my Mauser magazine-rifle.

We were quartered in two houses, and were quite comfortable. The men slept on "kitandas," low wooden benches, and were well provided for. The Sultan gave us one young ox, three sheep and a number of fowl, so that our supply of fresh meat was rich. The meat was tender and palatable.

That night the natives danced a war-dance by torchlight, in our honor, and at 6.30 A. M. on September 4th I began the march back.

In accordance with the wish of the Sultan, we marched by his house, where I took leave of him, after which I was conducted by Fumo Bakari and the Sherif of Witu as far as the gate. We crossed Lake Pangani at 11 A. M., when we halted for rest and cooked dinner. The march was resumed at 2 P. M., and at 4.30 P. M. we entered Fungasombo.

The return march from Witu to the sea was made in less time than before, because the men were fresher, and had started early in the morning. The men held out well, and entered Fungasombo singing. The man who had previously shown signs of weakness became helpless in crossing the lake, and was obliged to finish the journey on my horse. His helplessness was constitutional, and shortly after our return on board ship he recovered entirely. We encamped at Fungasombo that night, as before, but the swarms of mosquitoes made it impossible to get any sleep.

We left Fungasombo at 7 A. M., September 5th, and arrived at M'konumbi at 9 A. M., having had cloudy weather with light rain. It was very pleasant and agreeable. There were about 3000 head of cattle in the vicinity of M'konumbi, so that the men fared well on sweet and sour milk in abundance.

The boats from the ship came in at 2 P. M., and by 2.30 the detachment and baggage embarked in the boats and we proceeded with the ebb-tide. At 6 P. M. we anchored off Lamoo, because the tide was so low that we could not pass through the channel to Manda Bay. The men ate and slept for the night in the boats.

In the morning of the 6th of September I had an interview with Seleman Ben Hamed, who had been sent by his brother, the Bali of

Lamoo, from Kipini to pay his respects to me. He requested me to take a messenger with letters to Zanzibar, which I promised. I then bade farewell to Seleman and sent greetings by him to his brother, besides writing him a note, which I gave to Mr. Schlunke to interpret. We then returned to the ship, where we arrived a little after noon.

Further details as to the experience of the march are given in the reports of the Chief of the Detachment, Lieutenant Paschen, and Assistant Surgeon Tereszkiewiez.

I.—Equipment.

Though the expedition was of a friendly character, yet the officers and men were thoroughly equipped as if for a hostile object, upon the basis of an eight days' absence from the ship, as follows:

1. *Clothing.*—Straw hat, with havelock, undershirt, drawers, working blouse, working trousers, cape, woolen socks, boots, handkerchiefs, knife and sheath.

2. *Armament and Equipment Carried by Each Man.*—Two petty officers and twenty men were equipped with: Rifles, cutlasses, leather belts with two cartridge-boxes, each with twenty cartridges; haversacks with twenty cartridges, one day's ration of hard bread and sugar, gun-cleaning utensils, handkerchief, smoking utensils, and canteen of water with a little rum. Seven men also carried battle-axes, other seven had spades, and four carried camp kettles; these articles were carried by canvas slings over the left shoulder. Eight men (four servants, one hospital assistant, one musician, one porter, one steward) were equipped as follows: Cutlasses and belts without cartridge boxes, revolvers with eighteen cartridges, haversacks, canteens. The hospital assistant also carried bandages, while the musician carried his bugle.

3. *Equipments Carried in the Pack.*—(*a*) Undershirt, pair of drawers, working blouse, working trousers, pair of socks, pair of leather shoes, cap and cover, cape, comb and soap, towel, handkerchief, sewing-needles, white and black thread, some buttons, woolen blanket, waterproof cover. These articles were rolled in the blankets and waterproof cover and secured by three turns in the middle and at the ends. A wooden tablet with the name of the owner was fastened to the lashing.

Besides the above for each man, the pack also contained the following articles: (*b*) Three cases of reserve ammunition, each with

three hundred and eighty rifle cartridges and thirty revolver cartridges; large boiling-pot, smaller boiling-pot, three teakettles, thirty knives, forks and spoons, can of oil, gun-cleaning material, three lanterns, thirty candles, four large filterers, coil of lashings, eight reserve wooden tablets, about fifteen fathoms of old canvas to bind up broken packages, eight boxes of kindling-wood.

(*c*) *Provisions.*—Corned beef for three days, salmon for two days, preserved meat for three days—eight days; rice for four days, peas for two days, beans for two days—eight days; sugar for eight days; coffee for eight days; tea for eight days; hard bread for seven days, fresh bread for one day—eight days; butter for eight days; twelve litres of rum, one litre of vinegar; salt, pepper and onions.

The articles mentioned in (*a*), (*b*) and (*c*) were put in packages of about twenty-five to thirty kilogs. (55 to 66 pounds in weight). Four packages of blankets, etc., were tied together to make one bundle. Three mess chests were used to pack the articles mentioned under (*b*), and the provisions under (*c*) were carried in small chests; making a total of thirty-four packs; to which should be reckoned the seventeen bundles of equipments belonging to the officers.

II.—The Order of March.

The order of march was so regulated that one-half of the detachment was led by a petty officer; the bearers then followed; while the other half of the detachment, with the commanding officer and the surgeon, brought up the rear. In other respects the order of march was controlled by the road, which was so narrow that two men could not march side by side. The column was thereby considerably extended, so that it was difficult for the commander of the detachment to control the men and direct the march.

The stretch as far as the Fungasombo was made with cooler weather (with a fresh southerly wind), and covered in two and a half hours. The men also had occasional halts, whenever the bearers had to rest.

In the little village the site of the camp was selected for the night on dry ground covered with short grass, under the trees. Want of sufficient space prevented quartering in the huts. The first attempt at cooking failed entirely. The rice was burnt, and had to be thrown away. As the time for the midday meal had long been passed, coffee with corned beef and bread and butter was served out instead of a warm dinner. In the evening and during the night the camp was

infested by mosquitoes, and so much so that it was impossible to get any sleep. All attempts, such as covering one's self in the blanket, putting socks on hands and feet, pulling the caps down over the head by loosening the strings, etc., were in vain and gave no protection, even though a fire was kept burning all night near the camp to keep the mosquitoes away. At the inspection at midnight and 2.30 A. M. not a single man was found asleep. Some had gone to the fire, some had climbed up into the trees, as mosquitoes are said to confine themselves to a very limited height above the surface, and the others walked about the camp smoking. The next morning every one was covered with mosquito-bites, not only on the exposed portions, but also where the person was covered by underclothing and working dress. Two of the officers took refuge in a hut, and claimed to have found some protection under a mosquito net.

At daybreak the next morning the woolen blankets were rolled up and the men washed their faces and hands, but did not bathe, because there was a lack of water, and also because it was not advisable to expose the person to mosquito-bites. After breakfast the pack was rearranged, arms cleaned, and canteens filled with fresh filtered water with a little rum. At 6.30 A. M. the march to Witu was resumed. Shoes were worn for this portion of the march, as it was necessary to cross a swamp three feet deep, and it was deemed easier to do this in shoes rather than with the boots. The path led through grass four feet high, which farther along was eight feet high. At 9.30 A. M. we reached the swamp, which was crossed in forty minutes, and during this period the men were in the water up to their hips. The contents of the haversacks were wet. The passage of the swamp was rendered especially difficult by the marsh-grass, which necessitated raising the feet at every step to near the surface to disentangle them. The temperature was also higher on this day, and we missed the fresh sea-breeze which made the march to Fungasombo so pleasant. One man fainted while in the water. He was given some port wine and water, relieved of his weapons and equipments, and was soon able to resume the march.

On the opposite shore of the swamp the troops halted at 10.30 A. M., under the shade of some trees. A half ration of brandy was then served out, the men changed their clothes, and, while their wet clothes were hung up to dry, sought some rest, which here, as elsewhere during the entire march, was impossible on account of the mosquitoes. The march to Witu had to be resumed at 1.30 P. M. in order to be

able to reach that place before dark, and therefore there was not time to cook vegetables, and the midday meal was the same as that for the day before—coffee, corned beef, bread and butter.

During the four and a half hours' march to Witu we halted twice for about five or ten minutes. A part of the way led through a thick forest, which gave some protection from the sun. We arrived at Witu at 6 P. M. By direction of the Sultan, two large mud houses, one for the officers and one for the men, were placed at our disposal. These houses were found to be, like the entire village, remarkably clean and had been evidently unoccupied for a long period, for which reason we did not hesitate to use them. The men were comfortable, especially as the Sultan had provided resting-benches made of plaited straw, called "kitandas." There was ample space for all the men in the three sleeping-rooms, and the fourth served for stowing the arms and pack. One of the sleeping-rooms was used as a kitchen, and this use operated in driving away the mosquitoes and resulted in giving the men good rest at night.

We remained here three nights and two days, during which time the men had fresh provisions. One day dinner consisted of pork and beans, the next pork and rice, and on both days they were palatable. With a little money the men were able to buy fresh milk and eggs for breakfast and supper, so that nothing better could be wished for. There were no drills during our stay. The care of the clothes, washing, drying, and greasing boots and shoes, cleaning weapons and keeping the quarters clean and in order, occupied all their time sufficiently. Once the men were called out to review by the Sultan, and another time there was some target practice for the heir to the throne. In the evening the men had opportunity to bathe in a pond near the village, but in undressing and dressing they were so much exposed to mosquitoes that it was a questionable pleasure.

At 6.30 A. M., September 4th, we began our return march. The provisions for the first day consisted of fresh meat, cooked before our departure from Witu, and on the second day the chief meal consisted of corned beef and coffee. We arrived at M'konumbi at 11 A. M., September 5th, and at 2 P. M. the same day embarked in the boats.

III.—The Efficiency of the Equipment.

The equipment of the detachment proved to be thoroughly satisfactory, and it was found to be practicable to pack the individual articles belonging to the men in their woolen blankets. It is necessary, how-

ever, for the waterproof cover to be of strong material, by which the woolen blanket and its contents are preserved from injury in transportation. It would be advisable to have leather straps and buckles, to facilitate securing and opening the packages.

The straw hat proved to be a comfortable and convenient covering for the head, as it was light and rested securely without pressure on the head. The havelocks were made of too thin material to give the necessary endurance for a longer expedition.

The allowance of provisions was not satisfactory. Vegetables should not be taken on such an expedition. It requires too much time to prepare them. Such an expedition should take meat extracts, sausages, and preserved potatoes.

The camp kettles should always be taken on similar expeditions, for otherwise there would be nothing in which to get water for cooking or to filter with ; and it is not always practicable to camp in the immediate vicinity of water. These camp kettles are also convenient for carrying smaller articles, such as hard bread and tins of sausages and canned meats. They may be put in linen bags and stowed in the kettles, and during the halt may be taken out, and then put back after the march is to be resumed. Our men did this, and the articles in the kettles did not get wet on crossing the lake, and would have been dry in the heaviest rain. These camp kettles increase the weight to be carried, but they render it feasible to dispense with mess-gear and cooking-utensils, while they can contain a spoon and fork without liability to injury, which is otherwise not so likely. The camp kettles, carried by the men on the march to Witu in canvas straps, caused no complaints, and they are deemed to form an efficient part of the equipment. In case an expedition intends to halt for an entire day, it would be advisable to have larger cooking-kettles, wherein a meal for twenty-five men could be cooked at a time. If the large cooking-kettles are to be taken, the large spoons and forks must not be forgotten. It would also be advisable to take a pair of iron tripods sufficiently high to enable a fire to be kindled under them. These would have to go in the pack with the articles enumerated under (*b*).

IV.—Medical Outfit.

This consisted of the regulation allowance of tourniquets and bandages in a bag carried by a bearer, besides which the hospital assistant carried bandages, and the following in packages ready for immediate

use : Spiritus aetherus, liquor ammonii caustici, twelve quinine powders of 5 g. each, tincture opii, and eight boxes of salicylic tallow.

The following sanitary precautions were observed : The men were strictly cautioned not to drink any water which was not filtered in the large filterer carried with the expedition. But as the process of filtering the water occupied a long time, it was difficult to control the use of the small filterers which the men carried.

When sleeping at night without cover, a fire was kindled near the camp to drive away the mosquitoes by the smoke, but there was no appreciable benefit by doing so. It would be advisable on a similar march to have the men sleep in huts, or at least to select the site of the camp remote from trees, which are favorite resorts of mosquitoes.

In the morning of the second day's march the men rubbed their feet with the tallow. This precaution was well taken, as only three of the men became footsore. The men stood the journey to and fro very well. Only one man was overcome, and he was obliged to make two long stretches on horseback. Upon our return on board ship, all were well excepting slight swellings on the feet. Two of those who were footsore soon recovered, and the other one had to wear protecting bandages. The hospital assistant, Schliwa, had an abscess on the arm as a result of a mosquito-bite, and it was necessary to send him to the hospital for treatment.

U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

FORCED COMBUSTION.

By Cadet-Engineer J. E. Byrne, U. S. N.

While the gradual introduction of the triple-expansion engine is producing such marked increase in marine economy as 14.2 pounds of water per horse-power per hour, as shown by the diagrams of the trials of the Mascotte, and 13 pounds of water per horse-power per hour, as claimed for the Dynamo, ships carrying about 160 pounds pressure, an increase of fully 25 per cent. in the economy of ships of same power using steam of 95 pounds pressure, the question of high combustion is becoming daily a rival of equal importance in the minds of marine engineers. Where heretofore economy alone was the sole end, with a fair rate of speed, shipowners, especially of the Transatlantic lines, are becoming impressed with the belief that speed pays, and the immediate future will see ships of higher speeds rather than those of lower. In the naval marine of the world the importance of high speed has long ago become an established fact, and engineers recognize the fact that future improvements in the naval marine engine will be made greatly in this direction. Extremely high speeds necessitate light weights and high rates of combustion, regardless of economy, although the variance of the economy attained at fair speeds from that attained from extremely high speeds is not so great as it was formerly supposed it would be. While, however, the triple-expansion engine has advanced to a state of excellence, the general adoption and perfection of high rates of combustion have made but slow strides, owing to the insufficiency of the data relating to this important topic, especially with relation to the life of boilers, obtainable by the marine designer. Notwithstanding the evident advantages accruing from the present use of forced draught in vessels of war,

many difficulties will have to be overcome in the systems now in use before a state of perfection will be reached. The air-tight fire-room, with its many objectionable features, is at present probably the most used of known methods of increasing the supply of air.

During the months of August and September of the present year a series of experiments was performed at the Washington Navy Yard, under the supervision of the Bureau of Steam Engineering, for the purpose of determining with some degree of accuracy the rates of combustion, the evaporation, and the variations of air pressure at different parts of the boiler, under air pressures varying from .4 of an inch to 4 inches of water, in a particular type of boiler. The type of boiler used is that known as the "low" or "marine locomotive" type. It was originally designed with the furnace front filled with fire-brick. The blast was introduced into the ash pit, and the air, besides passing through the grate bars, passed up through holes in the dead plate, and thence through perforations in the lining of the furnace door, over the fire. Air was also allowed to enter through suitable holes into the bottom of the intermediate connection. With this arrangement the tops of the grate bars and bridge wall burnt off very rapidly, and the intermediate connection filled with coal dust and ashes to such an extent that the four lower rows of tubes were covered before the end of a four hours' experiment. Alterations being necessary, the brickwork was removed from between the furnace front and lining, the entire lining was perforated with holes to correspond with the furnace-door lining, and the front corner of the intermediate connection was filled with fire-brick, apertures being made for the admission of air into the intermediate connection. This arrangement worked so satisfactorily that the grate bars and bridge wall remained uninjured throughout the remainder of the experiments. Tabulated results of the experiments are given in Table No. I, and the principal dimensions of the boiler used are as follows:

Diameter of boiler, 7 feet; length of boiler, 15.25 feet; total grate surface, 21 square feet; total heating surface, 687.3 square feet; calorimeter, 5.3 square feet; steam space, 165 cubic feet; water space, 245 cubic feet; ratio of g. to h., 1 : 32.73; ratio of c. to g., 1 : 3.96. Tubes were of brass.

Jerrold's patent method of setting the fire ends of tubes, which consists of drilling the front tube sheet in such a manner that it can be beaded over on to the ends of the tubes, thus making a flush job and yet securing the tubes safely, was used for the purpose of determining its effi-

cacy in enabling them to withstand the intense heat of high rates of combustion. At the end of the experiments the tubes were found to be uninjured. The coal used was Cumberland Valley bituminous.

TABLE I.

NATURAL DRAUGHT.

Hours.	Coal per Hour.	Steam.	Ashes in Furnace and Ash-Pit in Lbs.	Ashes in Back and Intermediate Connections in Lbs.	Temp. Feed Water.	Pressure in Ash-Pit in Inches.	Pressure in Back Connection in Inches.	Pressure in Furnace Doors in Inches.	Water Evaporated per Lb. of Coal from and at 212° F.	Coal per Square Ft of Grate per Hour.
4	210	80	....	....	80	....	....	....	9.11	10
4	262.5	80	....	....	80	....	....	....	9.11	12½
4	315	80	....	....	80	....	....	....	9.93	15
4	367.5	80	....	....	83	....	....	....	9.50	17½
4	420	80	....	....	81	....	....	....	? 10.2	20
4	472.5	80	....	....	82	....	....	....	7.29	22½
4	525	80	....	....	80	....	....	....	? 8.19	25

FORCED DRAUGHT.

Hours.	Coal per Hour.	Steam.	Ashes in Furnace and Ash-Pit in Lbs.	Ashes in Back and Intermediate Connections in Lbs.	Temp. Feed Water.	Pressure in Ash-Pit in Inches.	Pressure in Back Connection in Inches.	Pressure in Furnace Doors in Inches.	Water Evaporated per Lb. of Coal from and at 212° F.	Coal per Square Ft of Grate per Hour.
4	577.5	80	200	208	78	.6	....	.6	8.24	27.5
4	630	80	180	264	78	1.1	....	.6	7.49	30
4	682.5	80	271	194	78	1.	....	.6	7.79	32.5
4	735	80	365	279	78	1.3	— .1	1.1	7.23	35
4	787.5	80	358	373	82	1.5	— .2	1.	7.24	37.5
4	840	80	350	425	79	1.7	— .2	1.2	6.61	40
4	892.5	80	390	475	80	2.6	— .4	2.	6.12	42.5
4	945	80	413	661	79	2.6	— .2	1.6	6.25	45
4	1050	80	560	1130	76	4	— .4	2.6	5.51	50
4	1050	80	552	1238	76	3	— .3	1.9	5.51	50

At this point the experiments were discontinued on account of the change of the function of the yard.

These results are apparently low, and do not equal those claimed to have been obtained in an article, by Messrs. Marshall and Weighton, read before the Institution of Naval Architects during the present year, and given in Table No. II., nor those obtained by the Admiralty with the ordinary locomotive type of boiler as used in the torpedo boats of Messrs. Thornycroft & Co., and given in Table No. III. Much of this disparity, however, can evidently be traced to the difference in the qualities of the coal used.

Table II.

Duration of Trial in Hours.	Ratio of Heating to Grate Surface.	Steam Pressure.	Coal per Square Ft. of Grate per Hour.	Evaporation per Lb. of Coal from and at 212° F.	Air Pressure in Stokehold.	Quality of Coal Used.
1.32	42.5	125.5	98.3	6.969	3.54	Cowpens coal, company's best.
1.23	42.5	125	107.9	6.889	3.605	do.
1.13	42.5	123	120.8	6.62	4.955	do.
1.5	42.5	120	118.1	6.566	3.07	do.
1.41	42.5	116.2	88.5	8.566	2.0	Nixon's Navigation, new and dry.

Table III.

Duration of Trial in Hours.	Ratio of Heating to Grate Surface.	Ratio of Grate Surface to Calorimeter.	Steam Pressure.	Coal per Square Ft. of Grate per Hour.	Evaporation per Lb. of Coal from and at 212° F.	Air Pressure in Stokehold.	Quality of Coal Used.
2	32.7	700	117	48.94	8.49	2	Nixon's Navigation.
2.1	32.7	700	117	62.2	7.90	3	do.
1.64	32.7	700	115	78.9	7.60	4	do.
1.48	32.7	700	115	96.03	7.15	6	do.

PROFESSIONAL NOTES.

[From *Tablettes des deux Charentes*, Sept., 1886.]

A series of experiments has just been made against the Bullivant nets surrounding the armored corvette Belliqueuse. The Minister wished to show that these nets cannot be efficacious except at a great distance from the hull, thus necessitating long spars difficult to handle, inconvenient to stow clear of the anchors, boats and guns; and, in short, he wished to show that the defenders of the Bullivant net are dreamers. In this case, as in the Protectrice experiments, the Minister took every precaution to cause the result to favor his own view; nevertheless he failed.

The charge was 55 kilograms of dry gun-cotton—three times the present charge of torpedoes—and the old wooden hull of the Belliqueuse was completely rotten. Nevertheless, in spite of these severe conditions, the results were as follows: At 9 m., no damage; 8 m., no damage; 7 m., oakum came out for two metres along a seam; 6 m., no damage; 5 m., no damage.

The effects having been nothing at 5 m. and 6 m., it was concluded that the oakum of a seam coming out at 7 m. indicated nothing, and was due to the defective caulking of such an old hull. Certainly an iron hull would have suffered no damage, and all experiments should regard only this class (iron) of armored vessels.

[From the *London Times*, Sept. 18, 1886.]

TORPEDO EXPERIMENTS AT PORTSMOUTH UPON THE RESISTANCE.

* * * * The former experiment had shown that the progress of a locomotive torpedo could be effectually arrested by the ordinary service protective nets now in use, and that the burst of a full-service charge of gun-cotton at the theoretical distance of 30 feet was perfectly innocuous. Yesterday morning the attack was advanced to closer quarters, and as the value of the nets had been demonstrated, it was deemed no longer necessary to employ costly Whiteheads in the assault. A fixed charge of gun-cotton, representing the normal explosive energy of a Whitehead, was accordingly slung from the booms at a distance of 20 feet from the skin plating (10 feet nearer than before) and submerged to the depth at which a torpedo would be set, and afterward electrically exploded from a cutter. The explosion produced the usual detonation and spout of water, but its force expended itself in the air, without inflicting any perceptible damage to the old hulk, which still continued to hold its own. A second charge of the same character and weight was afterward sunk 5 feet nearer the ship—that is, 15 feet from the side—and exploded in a similar way. In this case the differences were manifest and significant. * * * The Resistance was greatly strained and shaken, and though the booms remained in place, and none of the bottom skin was displaced, it began to leak, until eventually the wing passage in wake

of the target compartment became filled with water, and several runlets found their way into the bilges. Without docking the hulk it was found impossible to say what actual damage had been done.

The Resistance is an iron-armored broadside vessel of about 6000 tons, built about 1860.

TRIALS OF SMALL-ARM POWDER,

Showing the Progress Made by the Firm of Rottweil in the Past Three Years.

[From *Rivista di Artiglieria e Genio*, June, 1886.]

		Initial Velocity. German Service Powder. M.	Initial Velocity. Rottweil Powder. M.
11 mm. gun charge, 5 g.	Lead bullet, weight 25 g.	437	501
	Lead bullet covered with copper, wt. 25 g.	434	489
	Hardened lead bullet, weight 24 g.	449	512
	Internal pressure about equal for the three projectiles (atmospheres).	1484	2275

The useful gain was thus 60 m. of velocity, with undesired increase of 800 atmospheres.

Later trials give:

		Initial Velocity. M.	Internal Pressure. Atmospheres.
9 mm. gun with hardened lead bullet of 15.5 g.	German service powder, 4.3 g.	505	1625
	Compressed Rottweil powder, No. 5, 5.2 g.	558	1655
	" " " No. 7, 5.2 g.	583	1530*
	" " " No. 15, 5.2 g.	600 †	1655

W. L. R.

ORDNANCE NOTES.

Serving and Operating Guns on Board Ship.

The weight of the new service ammunition (of calibres above 6 inches) is so great as compared with that of the old, that the existing methods of handling it are likely to produce serious delays in loading. It is the intention of the Bureau of Ordnance to substitute, where necessary, mechanical power for manual labor in this connection, and a study is now in progress of the best means to the desired end. It is not impossible that ships of similar type may be equipped in different ways, in order to establish practically the relative value of steam, compressed air, water and electricity as vehicles for conveying and utilizing the energy required. Each of these prime motors presents certain disadvantages. Thus, in the event of rupture of the conduits, much inconvenience would arise if they carried either steam or water, both on account of the escaping matter and the difficulty of effecting rapid temporary repairs.

* Less smoke and less residuum in the barrels.

† The ordinate at 150 m. of the 300 m. trajectory is 46.4 cm.

Compressed air is subject to the last-mentioned drawback. On the whole, electricity bids fair to become a formidable rival to steam, air and water through the ease of laying and mending the conductors. Already certain electric motors command serious attention through compactness of design and efficiency in operation. These, as well as steam, air, and water engines, will be used not only to run in and out, train and point the guns, but, in addition, to hoist and haul shot and powder and to sponge and load guns. The results of this competitive trial will be of great interest to the naval profession, and will possibly solve other problems of ship economy, such as winches, capstans, boat hoists, etc.

Electric Firing of Guns.

Electricity has already been used in our Navy for simultaneous and other firing, the source of electricity being apart from the guns. For individual firing, the voltaic cell and secondary battery have been carried by the gun captain. It is proposed to lessen the inconvenience to him by placing the cell or battery on the slide or top carriage, as may prove most desirable.

C. F. G.

The 8-inch B. L. R. No. 1 (Mark 1), of steel, constructed at the Washington Navy Yard for the U. S. S. Atlanta, has been fired twelve (12) times at the Naval Ordnance Proving Ground with results as shown in the following table:

Charge.	Projectile.	I. V.	Pressure.
85 lbs.	250 lbs.	1706 fs.	11.6 tons.
100	250	1804	12.3
110	250	1966	15.9
110	250	1914	15.7
110	250	1858	12.8
110	250	1845	12.5
120	250	1990	14.4
120	250	1985	14.5
120	250	1977	14.8
122	250	1999	15.2
122	250	1980	15.2
123	250	2013	15.5

The gun was fired for the purpose of testing the gun and carriage, and to develop powder for guns of its calibre. The carriage used was the gravity-return barbette carriage shown in Plate 11, Report of Secretary of Navy, 1885. The gun has developed no defects of any kind, the breech mechanism and gas check (De Bange) working well. The carriage proved itself strong and capable of handling the gun with ease during elevation, training, recoil and counter-recoil. C. E. B.

The Statutory Tests of the 6-inch and 8-inch B. L. R.'s.

On November 4, 1886, the rapid-firing test ordered by Congress was made before the Board detailed by the Secretary of the Navy, composed of Captain John A. Howell, Lieutenant John F. Meigs and Lieutenant A. M. Knight, U. S. Navy. The Superintendent of the Naval Academy and a large number of officers were present to witness the tests. The firing was under the immediate charge of Lieutenant Knight, with gun-crews composed of the regular employes of the Ordnance Proving Ground, some of whom were colored laborers. After every round the guns were quickly sponged with a very wet sponge. The heating of the guns was not great, and the hand could be held against them

after the firing of the ten rounds. The projectiles were fired into an embankment within 100 yards distant. The following data present a showing that will be of great interest to the service—viz. :

8-inch B. L. R. (on barbette carriage) : Projectile, 250 pounds ; charge, 121 pounds Westphalian powder ; initial velocity, 1991 f. s. ; pressure, 14.6 tons per square inch ; time of firing ten rounds, 15 minutes and 7 seconds ; number of men in crew, 8.

6-inch B. L. R. (on broadside carriage) : Projectile, 100 pounds ; charge, 50 pounds Dupont's brown prismatic powder ; initial velocity, 2025 f. s. ; pressure, 14.9 tons per square inch ; time of firing ten rounds, 11 minutes and 43 seconds ; number of men in crew, 8. J. W. D.

FRANCE.

[From *Le Courier des États Unis.*]

The Hoche was launched at L'Orient October 1, 1886. This vessel is 334.5 feet long, 65 feet 7 inches breadth of beam, draws 28 feet 3 inches and displaces 10,581 tons, has a double bottom for a portion of her length, and is divided into numerous water-tight compartments by bulkheads both fore and aft and athwartships ; is protected, 1st, by an armored deck 3.6 inches thick, which extends from one end to the other, and protects all the vital parts—*i. e.*, engines, boilers, steering gear, etc., etc.; 2dly, by an armored shield the plates of which are 17.7 inches at the upper end and 13.77 inches at the lower. The coal bunkers also protect the engines and boilers. Finally, a part of the bow has been filled with cellulose matter, which has given excellent results in stopping leaks.

Armament.—Two 14.56-inch guns in closed turrets, situated on the fore and aft line of the ship, one forward and the other aft. (These guns weigh 75 tons, throw a conical projectile weighing 1232 pounds, capable of piercing a plate of wrought iron 24.4 inches thick at a distance of 3280 feet.) Two 13.38-inch guns in barbette turrets, one to starboard, the other to port (these guns weigh 52 tons), throw a conical projectile of 924 pounds, and can pierce 22.84 inches of wrought iron. Finally, eighteen 5.5-inch guns ; revolving and rapid-firing guns, the number of which has not yet been determined, and 6 tubes for launching auto-mobile torpedoes. The turrets will be covered with 13.75-inch armor. The Hoche has two military masts with tops, in which are revolving cannon.

The motive power consists of two independent engines, placed beneath the armored deck and separated by a strong midship bulkhead ; each engine works a screw. Full horse-power 12,000. The speed should be 16½ knots. The Marceau, a sister ship, was launched at Toulon in 1884, and will be finished next year (1887). Two others of the same class are building—the Neptune, at Brest ; the Magenta, at Toulon.

A new class of coast-guard armored ships is building in France. The six first-class are named Tonnant, Furieux, Tonnerre, Fulminant, Vengeur and Tempête. These formidable engines of war measure as follows : Length, 248 feet on water-line ; beam, 57 feet 9 inches ; depth, 18 feet ; draught of water, 16 feet 9 inches ; displacement, 4523 tons. The armor is 9.8 inches forward, 13 inches amidships, and 9.5 inches aft. The battery consists of two 13.4-inch turrets, one forward, the other aft, and four revolving guns on deck. The turrets are protected by plates 13.75 inches thick. 197 men compose the crew. Six of the second class of coast-defense vessels have also been ordered, which will have less armor and smaller guns.

A rifle 8 millimetres (.315 inch) has been invented and perfected by some infantry officers at Chalons. There are two models of this rifle, one single-fire, the other repeating. The first is preferred by competent judges, but it is difficult to persuade the masses that a single-fire rifle is preferable to a repeating rifle; hence, it is probable that the latter will be adopted. This small-calibre rifle has ballistic qualities superior to any yet tried. The projectile is very long, with a very fine covering of brass or steel, which strengthens it completely, and preserves its shape. The ball has an initial velocity of more than 1640 feet per second. The powder has been specially prepared for this rifle, and belongs to the category of progressive powders; that is to say, it is one which makes the recoil not a shock, but a push. It makes but little report, and so little smoke that, at a short distance even, one might not have his attention attracted. The trajectory is so straight that, at a distance of 1900 feet, it only rises 6 feet 6 inches. The Ministry of War hopes to obtain the necessary funds to complete the change of rifles.

Germany has decided to arm all troops with repeating rifles. It is said that the Government manufactories and arsenals have been ordered to transform the Mauser rifle, now in use in the army, into a repeating rifle of ten shots.

A shell is mentioned as being experimented with in England. It is made of steel, can perforate an iron target 18 inches thick, and can sink the largest ironclad afloat. This shell is a French invention.

The English are also going to try the new Schulhoff rifle, which fires 24 rounds a minute. On pressing a spring one can change it into a double-arm firing 52 shots a minute. This weapon will probably be adopted by the Austrian Army.

Experiments have taken place in the Department of Aisne, France, with shells filled with a substance of which the French Government holds the secret of its manufacture. Its power is double that of mélinite. There is no more danger in handling it than there is with ordinary powder. Its use will diminish the calibre and weight of guns. D. H. M.

THE STEAMSHIP AMERICA.

[From *Transactions of the American Society of Civil Engineers*, April–July, 1886.]

From the paper on the steamship America, by Robert Gordon, the following is taken as of general interest: In the shape of her hull, the America is the embodiment of principles discovered by the late Mr. W. Froude, who, while experimenting on models of ships, found, contrary to the expectation and practice of naval architects, that a comparatively short and broad ship, with fairly fine entrance and exceedingly fine run aft, carried on continuously curving lines throughout, could be driven at a higher rate of speed with a less expenditure of power than a long and narrow ship of the same capacity with fine entrance and parallel-sided body. Probably the greater amount of skin friction in the latter vessel might account for this result, but the relation of the resistances arising from this, and from the generation of waves in deep water, to the shape of the ship, at different speeds, still requires some elucidation.

The City of Rome is 600 feet long over all, with an extreme breadth of 52 feet and depth of hold of 37 feet. Her midship cross-section on 26 feet draught is about 1300 square feet, and her displacement at that draught 13,500 tons. The indicated horse-power of the engines exceeds 14,000. The

America is 459 feet in length (extreme) and 51 feet in breadth, and her depth amidships is 38½ feet. On 26 feet draught her cross-section is 27 square feet less than that of the City of Rome, and her displacement is 8830 tons. The former vessel averages 16 knots on a coal expenditure of over 300 tons per day, while the America averages 18 knots on a consumption of 180 tons per day.

With a length between perpendiculars of 432 feet and a beam of 51 feet, the America has a depth amidships to the upper deck of 38½ feet, and to the promenade deck of 47 feet. The promenade deck is 250 feet long; and, if it were continuous throughout, or made so that the strains could be transferred by suitable struts and ties, the vessel might be considered as a girder, with upper and lower chords 47 feet apart; but, as it is, she is treated by the builders as a beam of but 38½ feet depth, and they have used steel with a compressive strain of 32 to 36 tons per square inch above the neutral axis, and of 29 tons below it. The material throughout is mild steel. There are three decks continuous throughout the vessel: the upper deck; the main deck, at 29½ feet, and the lower deck, 21¼ feet above the bottom of keel; while an orlop deck is fixed at 13½ feet wherever the arrangement of machinery permits. The frames are spaced 27 inches, and the flooring beams 54 inches apart, and two rows of stanchions are placed under beams wherever practicable. Extremely strong web frames and reverse frames are carried through the machinery rooms; and four keelsons on each side of the centre keelson suitably stiffen the vessel longitudinally. The plating varies in thickness from ½ to ¾ inch, butt-strapped and treble-riveted. Eleven water-tight bulkheads, carried to the upper deck, divide the ship into 12 compartments, the longest of which does not exceed 48 feet; and any two of these may be filled with water without sinking the vessel. The bulkheads are from five to seven-sixteenths of an inch in thickness and are well stiffened. Three coal bunkers carry together 1650 tons of coal.

The engines of the America are direct-acting, with one high-pressure cylinder of 63 inches diameter, and two low-pressure, each 91 inches diameter, with 66 inches stroke. Each cylinder has four piston valves, coupled two and two above and below—the high-pressure of 25 inches diameter and 9 inches stroke; the low, 32 inches diameter and 12 inches stroke. The steam enters from the boilers at 90 pounds pressure and passes from the high-pressure cylinder to the reservoir at about 26 pounds pressure, whence it is taken through the low-pressure cylinder, expanding, to the condensers, where a vacuum of 26 inches is easily maintained by the air-pumps and the action of two Gwynne's pumps, throwing from four to five thousand tons of water per hour through the condensers. These are worked by separate engines of about 40 indicated horse-power. The total tubular surface in the condensers is about 12,000 square feet. Two air-pumps, of 36 inches diameter and 33 inches stroke, are worked by the main engines. The estimated power of the engines is over 7000 horse-power. Six double-ended boilers, 17½ feet long and about 14 feet diameter, produce steam at 90 pounds pressure, while an extra single-ended boiler, 11 feet long and 15 feet diameter, furnishes steam at 95 pounds pressure. The total grate surface of the seven boilers is 883 square feet; the tubular surface about 21,000 square feet. The total weight of the boilers is about 333 tons, and they are constructed of steel plating from $\frac{15}{16}$ to 1 inch thick. Each boiler carries three safety valves of 5⅜ inches diameter, all inaccessible. Two oval-shaped funnels, each divided longitudinally by a diaphragm, rise 100 feet above the keel of the ship. The engines are provided with Dunlap's governor, and special starting-gear, arranged so that the speed can be adjusted independently of the governor. It is found that 65 to 66 revolutions of the engine give a speed of about 18 knots through smooth water, while 68 to 70 carry the vessel at about 19 knots. The crank shafts are of steel. The propeller shaft is of forged scrap-iron, 36 feet long and 22 inches diameter. The thrust is carried by ten collars, with about 3000 square inches of bearing. The propeller is four-bladed, 22 feet in diameter. The leading side has a regular pitch of 29 feet;

the following side a pitch varying from 24 to 34 feet. The blades are of manganese bronze; the boss is of steel. The weight of the former is about 15 tons; of the latter, about 9 tons with the bolts. The total surface of the four blades is 164 square feet. The between-deck spaces are connected with ventilating tubes which terminate in the chimneys. A complete system of drainage from the cabins, decks, and bilges is made by pipes and pumps worked by the engines. P. F. H.

THE LUNAR SURFACE AND ITS TEMPERATURE.

In *Nature*, impression of July 15, 1886, there is a very interesting discussion of this subject by John Ericsson. The paper will be found also in the *Scientific American* supplement of August 14, 1886. The writer rejects the hypothesis of a volcanic origin of the walls of the great "ring mountains" of the lunar surface, and argues that they are inert glaciers which have become as permanent as granite mountains by the action of perpetual intense cold.

Discussing the maximum temperature which solar radiation is capable of imparting to the lunar surface, it is proved that when the earth is in aphelion the temperature of the lunar surface when presented to the sun can only be augmented 81.11° F. Captain Ericsson has devised a pyrheliometer, by means of which he has shown that the moderate heat produced by solar radiation is capable of increasing the temperature of bodies, previously heated to a high degree, by an amount which depends upon the intensity of the sun's rays. Regarding the temperature prevailing during the lunar night, its exact degree is not of vital importance in establishing the glacial hypothesis, since the periodical increment of temperature produced by solar radiation is only a fraction of the permanent loss attending the continuous radiation against space resulting from the absence of a lunar atmosphere; besides, all physicists admit that it is extremely low.

The formation of annular glaciers by the joint agency of water and the internal heat of a planetary body devoid of an atmosphere and subjected to extreme cold is readily explained on physical principles. Suppose a sheet of water on the moon's surface covering the same area as the plateau of Tycho—viz.: 50 miles in diameter and 1960 square miles in area. Suppose, also, that the internal heat of the moon is capable of maintaining a moderate steam pressure, say 2 pounds to the square inch, at the surface of the water in the pond. The attraction of the lunar mass being only one-sixth of terrestrial attraction, while the moon's surface is freed from any atmospheric pressure, it is evident that under the foregoing conditions a very powerful ebullition and rapid evaporation will take place, and that a dense column of vapor will rise to a considerable height above the boiling water. It will also be evident that the expansive force within this column, at the surface of the water, will be so powerful at the stated pressure that the vapor will be forced beyond the confines of the pond in all directions with great velocity. No vertical current, it should be understood, will be produced, since the altitude of the column, after having adjusted itself to the pressure corresponding with the surface temperature of the water, remains stationary, excepting the movement consequent on condensation from above. The particles of vapor forced beyond the confines of the pond, on being exposed to the surrounding cold, caused by unobstructed radiation against space, will crystallize rapidly, and in the form of snow fall in equal quantity round the pond, and thereby build up an annular glacier.

Captain Ericsson discusses other features of the moon's surface, with the causes of formation, in this most interesting and instructive essay.

P. F. H.

ON BANKED FIRES.

[Translated from *Die Schiffsmaschine* by W. F. WORTHINGTON, P. A. E.]

It is a widespread error to suppose that banking fires, especially in large boilers with large water spaces, even for two or hree days at a time, is more economical than hauling fires and starting them again.

By referring to the accompanying table, in which are given data collected from the ships named, it is seen that the amount of coal required to keep banked fires in large boilers for about 20 hours, and in small ones for about 30 hours, is equal to the amount required to start the fires.

The quantity of fuel required to heat the water is not considered, because it is about the same in either case. From the table it is seen that with banked fires the weight of coal per furnace per hour is, for small boilers, 16 to 18 pounds; medium, 22 to 24 pounds; large boilers, 26 to 31 pounds; and for starting fires it requires on an average, in round numbers, from 21 to 25 pounds per square foot of grate. Taking into consideration that banking fires is only economical when the period for which the engines are to be stopped does not exceed about 24 hours, and that even in this case the life of the boiler is much shortened, we must conclude that fires should never be banked for more than a few hours except when anchored in an unsafe harbor, or in such cases where the exigencies of the service may require the use of the engines at very short notice.

EXTRACT FROM TABLE IN "DIE SCHIFFSMASCHINE."

Name of Vessel.	I. H. P. of the Engines, Approximately.	Average weight of coal required in pounds.				Number of hours in which the amount used under banked fires becomes equal to amount required for starting fires.	Remarks.
		For starting fires.		Under banked fires.			
		In all furnaces	Per sq. ft. of grate.	For all fires for 24 hrs.	For one fire per hour.		
König Wilhelm	8000	22,047	24	26,456	28	20.0	The banked fires are kept in condition to raise steam at half an hour's notice.
Kaiser and Deutschland	8000	26,456	30	30,865	32	20.5	
Kronprinz	4800	17,640	24	19,845	26	21.3	
Friedrich Carl	3500	13,230	23	22,047	35	14.4	
Preussen	5400	13,230	19	19,845	28	16.0	
Friedrich der Grosse	5400	16,537	24	22,047	31	18.0	
Sachsen and Class	5600	22,047	30	21,168	28	25.0	
Leipzig and Class	4800	17,640	28	15,432	23	27.4	
Bismarck and Class	2500	8,820	23	10,584	22	20.0	
Hertha and Vineta	1500	7,938	28	8,820	23	21.6	
Mars	2000	12,127	28	10,584	22	27.5	
Ariadne and Louise	2100	7,717	29	7,716	23	24.0	
Nymphe	800	3,969	30	3,306	17	28.8	
Zieten	2350	6,615	28	4,409	15	36.0	
Loreley	350	1,654	24	2,117	22	18.7	
Habicht and Möwe	600	2,646	25	1,764	18	36.0	
Albatross and Nautilus	600	2,646	23	2,205	15	28.8	
Wolf and Class	340	1,654	28	1,587	17	25.0	

W. F. W.

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PROCEEDINGS OF THE ROYAL ARTILLERY INSTITUTION.

MAY. Notes on the method of compiling a range-table, by Commander H. J. May, R. N. The trajectory for the cubic law of resistance, by A. G. Greenhill, M. A. The march of the right division Hazara Mountain Battery, by Lieutenant A. H. C. Birch, R. A.

JUNE. Short history and description of armor and its attack by artillery, by Captain Orde Browne (late R. A.) Vertical fire in the field, and how the question is regarded in Russia, by Captain E. S. May, R. A. Shield or shelter, by Major T. B. Tyler, R. H. A. Extracts from the "History of the Royal Artillery," by Lieutenant-Colonel Jonas Watson. A simple method of range-finding from coast batteries when in signaling communication with each other, by Colonel Stapleton Penny, R. A.

JULY. The volunteer field battery, Bechuanaland field force, by Major E. A. Ollivant, R. A. Report of experiments with Nordenfelt's submarine boat, by Lieutenant J. H. Thomson, R. H. A. Remarks on fortification, by Lieutenant C. E. Callwell, R. A. The general arrangement and practical working of the artillery defense of a first-class fortress protecting a harbor and dockyard (the gold-medal prize essay), by Major A. W. White, R. A.

AUGUST. Proposed system for checking the recoil of field guns, by Lieutenant F. R. Maunsell, R. A. Extracts from the diary of Captain Pococke, 71st Highland Regiment, while a prisoner in Buenos Ayres, 1806–1807; contributed by Lieutenant-Colonel Duthie (late R. A.). Use of portable rails; moving two 38-ton guns on portable rails to Colaba Point Battery, by Colonel Stapleton Penny, R. A. Arming the *personnel* of horse and field artillery, by Captain E. A. Lambart, R. A. The general arrangement and practical working of the artillery defense of a first-class fortress protecting a harbor and dockyard (the silver-medal prize essay), by Major R. W. Rainsford-Hannay, R. A. The commended essay, same subject, by Captain E. Nash, R. A. On the rejection of abnormal rounds in trials for accuracy of shooting, by Major H. W. L. Hime, R. A.

SEPTEMBER. Précis of Lydd experiments, 1882–3, by Colonel F. G. Baylay, R. A. Landing the 110-ton b. l. gun at the Royal Arsenal, Woolwich, by Col. J. T. Barrington. Artillery, a review, by Captain J. M. Grierson, R. A.

UNITED STATES ARTILLERY SCHOOL.

ARTILLERY EXERCISES.—CLASS A. Description and service of machine guns, Gardner gun, Hotchkiss revolving cannon, Hotchkiss 1.65-inch b. l. mountain gun. The 0.45-inch Gatling guns, old and new models, by Captain John H. Calef, Second Artillery. Notes on experiments with high explosives, Fort Monroe, Virginia, May, 1886, by M. M. Macomb, First Lieutenant Fourth Artillery. Comparisons of the armaments of European nations, describing their systems of artillery, by A. D. Schenck, First Lieutenant Second Artillery. Notes on the distribution of iron ores in the United States, compiled from various geological reports, by Anthony W. Vogdes, First Lieutenant Fifth Artillery.

The following essays: Defensive and offensive weapons and engines of the ancients and of the Middle Ages; their relation to the constitution and handling of armies, and their effect upon the art of war, by John R. Williams, First Lieutenant Third Artillery. An historical account of the development of small arms and ammunition for the same, and the effect of the same upon the science of war, by Charles A. Bennett, Second Lieutenant Third Artillery. Military Geography of the Dominion of Canada, by A. D. Schenck, First Lieutenant Second Artillery.

By the author: Report on the Grand Manœuvres of the Seventeenth Corps of the Army of France, by First Lieutenant John P. Wisser, First Artillery, Vancouver Barracks, W. T.

JOURNAL OF THE ROYAL UNITED SERVICE INSTITUTION.

The field telegraph, its use in war and its employment in the late expeditions in the Soudan and South Africa, by Major C. F. C. Beresford, R. E. The defense of London and of England. Part I. The security of London against a *coup de main.* Part II. The successive stages of the defense, by Major H. Elsdale, R. E. The defense of the coasts of England, Ireland and Scotland in the event of war, by Rear-Admiral W. Arthur, C. B. Mounted Infantry, by Major E. T. H. Hutton, King's Royal Rifles. A Reserve of Horses, by Colonel F. G. Ravenhill, R. A. To find the deviation of a rifle-bullet due to the rotation of the earth, by J. H. C. Dalton, B. A.

R. R. I.

LITERATURE OF EXPLOSIVES.

INDEX TO PART I., by Charles E. Munroe, S. B. (Harv.). Printed and sold by Friedenwald, Baltimore, Md.

AMERICAN ACADEMY OF ARTS AND SCIENCES.

PART II., FROM OCTOBER, 1885, TO MAY, 1886. This valuable number contains:—XXIII.: Measurement of the strength of telephone currents, by Chas. R. Cross and James Page.

A form of electrical balance similar to that figured by Maxwell (*Electricity and Magnetism*, 2d Ed., Vol. II, 342) was at first constructed, but this failed to

give satisfactory results. Subsequently success was obtained by using a Kohlrausch unifilar electro-dynamometer, made by Hartmann, of the form described by *Wiedemann's Annalen*, Vol. XV, 1882, p. 550. Measurements were made with the Hunning, Fitch, Blake, Edison and Bell magneto transmitters. The Hunning transmitter uses carbon in a granulated form, and the Fitch employs two hard carbon discs as electrodes. The vowels *a*, *o*, *u*, *i* (German sounds) were spoken or sung into the transmitter successively, all at the same pitch—viz. : the *B* of 480 vibrations—and with the same intensity, as nearly as this could be realized. The deflections obtained are given in full in readings in centimetres and tenths. Several series are given. Very interesting results were obtained.

XXIV. Experiments with the thermal telephone, by Chas. R. Cross (Rogers Laboratory of Physics).

XIV. Early experiments in telegraphing sound, by Edw. C. Pickering.

XV. and XVI. Atmospheric refraction, by Edw. C. Pickering.

XVII. A new form of polarimeter, by Edw. C. Pickering.

XX. Observations of variable stars, 1885, by Edw. C. Pickering.

XXI. On the methods of study of thunderstorms, by W. M. Davis.

A very important paper detailing the methods of systematic study of thunderstorms in France, Norway, Russia, Belgium, Italy, Bavaria, Netherlands, Saxony, Central Germany, Switzerland, and by the United States Signal Service. In the discussion of observations the author gives a simple and ingenious method of portraying storms.

XVIII. A new logical machine, by Allen Marquand, Ph. D.

XXII. The dynamic action of an electric current, by Hammond Vinton Hayes.

XXIII. On conditions that determine the length of the spectrum, by Amos E. Dolbear.

J. W. D.

AMERICAN GEOGRAPHICAL SOCIETY BULLETIN.

No. 1, 1886. Mountaineering in British Columbia, by Ernest Ingersoll. Persia and the Persians, by S. G. W. Benjamin, Ex-Minister to Persia. Geographical notes, by Geo. C. Hurlbut.

AMERICAN IRON AND STEEL ASSOCIATION.

CORRECTED TO JULY 15TH, 1886. Directory to the iron and steel works of the United States, embracing the blast furnaces, wire mills, pipe works, etc.

NOS. 20 to 35 (both inclusive) contain much useful information about the metals.

"Twenty-one Years of Progress in the Manufacture of Iron and Steel in the United States," by James M. Swank, General Manager American Iron and Steel Association (conclusion).

"It has been the object of this paper to exhibit the astonishing progress of the United States in the manufacture of iron and steel in the last twenty-one years, and to show the prominence of our country as a producer of these essen-

tial aids to modern civilization. With an abundance of good ores and good fuel, including under the latter head our great stores of natural gas, we must soon become the first iron and steel-producing country in the world, as we have long been the largest consumer of these products. Only Great Britain excels us in the production of pig iron and steel, but we annually consume more of each product than our great rival. We consume to-day one-fourth of all the pig iron and one-third of all the steel that the world produces."

AMERICAN SOCIETY OF MECHANICAL ENGINEERS, TRANSACTIONS OF.

VOL. VII, 1886, is a valuable contribution to engineering literature, containing: The President's Address for 1885. The basic Bessemer process. Rapid transit and elevated railroads. Twist drills. The frictional resistance of shafting in engineering establishments. The unexpected which often happens. The microscope in the workshop. A new form of steam calorimeter. Improvement in ferryboats, by Wm. Cowles, member U. S. N. I. The rating of steam boilers by horse-powers for commercial purposes. Crystallization of iron. Experiments on the transmission of power by gearing. Standard pipe and pipe threads. Steam-engine tests at Massachusetts Institute of Technology. The course in mechanical engineering at Massachusetts Institute of Technology. Notes on the comparative value of metal surfaces for warming air. Topical discussions. The engineer as an economist. Another new steam indicator. The production of true crank shaft and bearing. Substitutes for steam. The relative efficiency of centrifugal and reciprocating pumps. The engineer as an economist, by H. R. Towne, member U. S. N. I. The training of a dynamic engineer in Washington University, St. Louis.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS, THIRTEENTH MEETING AT CHICAGO.

The production of true crank shafts and bearings, by Horace See, member U. S. N. I., Philadelphia, Pa., Supt. Engineer of Wm. Cramp & Sons, S. & E. B. Co.

This paper describes the plan by which the shafts of the steamships Mariposa, Alameda, San Pablo, H. F. Dimock, Eureka, El Paso, El Dorado, Philadelphia, and yacht Atalanta, were fitted. "Some 25,000 nautical miles have been run before readjustment has been necessary, and 135,000 before wear of journal and bottom box combined amounted to the one-fiftieth of an inch."

AMERICAN PHILOSOPHICAL SOCIETY.

VOL. XXIII, JULY, 1886, NO. 123. The glaciation of parts of the Wyoming and Lackawanna Valleys. Composite photography applied to handwriting. The use of oil in storms at sea. And several other scientific papers.

CANADIAN INSTITUTE, TORONTO, PROCEEDINGS OF.

VOL. XXI, JUNE, 1886, NO. 145. Goldmining in the Saskatchewan, by Chas. Levey. Extinct cuttle-fish in the Canadian Northwest,

by A. McCharles. The alimentary canal in ganoid fishes, by A. B. Macallum, B. A. Ancient Egyptian language, by Rev. George Burnfield.

CITY RECORD, OFFICIAL JOURNAL, NEW YORK.

JUNE 28, 1886. Preliminary report on the progress made in paving Fifth Avenue, by Colonel George T. Balch, member U. S. N. I.

SEPTEMBER 28, 1886. Contains (pages 2299 and 2300) report of Colonel George T. Balch. Where the responsibility lies for the "violation of the law and the contract described in this report" (Repaving of Fifth Avenue). J. W. D.

TRANSACTIONS OF THE AMERICAN SOCIETY OF CIVIL ENGINEERS.

APRIL–JULY, 1886. The South Pass jetties. The spongilla in main pipes. On the accuracy of a system of magnetic bearings of a survey. Mexican bridge construction. Excavation and embankment by water power. Permanent transmitting dynamometer. Data for flattening the ends of railroad curves. On cranes as labor-saving machines. Thermometer scales. The steamship America. On specifications for strength of bridges. On the strength of columns. New formula for compression members. P. F. H.

BULLETIN DE LA RÉUNION DES OFFICIERS.

No. 34, AUGUST 21, 1886. On military schools in Germany. Application of the telephone in war (illustrated).

No. 35, AUGUST 28, 1886. Completion of article "The Telephone in War."

No. 36, SEPTEMBER 4, 1886. Extract from *La Spezia* on experiments with a 100-ton Armstrong gun against armor plates. Trials of April 20, 24 and 29, 1886, at Spezia, Italy.

No. 39, SEPTEMBER 25, 1886. Commissariat service in the Austro-Hungarian Army; also, the preparatory school for cavalry in France.

No. 40, OCTOBER 2, 1886. New campaign stove (illustrated). Supplying ammunition on the field of battle, as in the Austro-Hungarian Army. Repeating rifles; with extracts from a book written by M. Hebler on "The Least Calibre; or, the Coming Rifle for Infantry Use." D. H. M.

JOURNAL DU MATELOT.

No. 27, 1886.

During the survey of the New Hebrides archipelago the French ship Dives discovered, on the 30th March, an excellent anchorage in the island Urèparapara, into which no vessel had ever been. It was carefully surveyed and named Dives Bay in compliment to the ship.

No. 39, 1886. An account of an electric-lighted life buoy for men-of-war or other vessels fitted with dynamo machines.

The light of this buoy can be also used for a stern light, when Article 11, Rules of the Road, has to be complied with. D. H. M.

MECHANICAL ENGINEER.

JUNE 26, 1886. The U. S. S. Puritan.

Cross-sections through the pilot-house of new and old Puritan are given, and table showing that the new ship compares favorably with the Conqueror and Tonnerre.

Description and drawings of the novel and ingenious ash-hoist engine of the U. S. S. Atlanta.

JULY 10, 1886. List of dry-docks of the United States exceeding 58 feet breadth of entrance:

Port.	Kind of Dock.	Dimensions of Dock.			Dimensions of Largest Vessel that can be taken in.			
		Length over all.	Width of entrance.	Depth on sill, spring tides.	Length.	Beam.	Draught.	Tons.
		Ft	Ft.	Ft.	Ft.	Ft.	Ft.	
Buffalo	Basin	350	60	10	...	...	...	..
Detroit	Basin	308	65	13	...	...	...	2000
Detroit	Basin	360	75	11.5	...	...	...	2000
Albina, Oregon	Basin	400	72	28	...	...	...	...
San Francisco	Floating	210	60	20	...	...	...	1500
San Francisco	Basin	450	90	24	438	...	...	...
San Francisco	Basin	529	78	26.5	460	78	27.5	9000
Portland, Me	Basin	425	80	24	...	...	18	...
Portsmouth, N. H.	Floating	350	90	23	350	90	23	5300
Boston	Basin	379	60	25	354	60	25	8000
Boston	Basin	365	64	17.5	352	64	17.5	...
Brooklyn	Basin	350	66	25	350	66	25	7500
Brooklyn	Basin	540	100	22	510	70	22	...
Brooklyn	Basin	630	85	25	567	56	25	...
New York	Balance	330	90	18.5	...	...	...	...
New York	Sectional (10)	360	100	20	400	95	19	6000
New York	Sectional (8)	250	75	16	...	...	14	3000
New York	Sectional (6)	170	65	16	...	...	14	1500
Jersey City	Balance	185	62.5	14	...	...	...	1200
Philadelphia	Basin	434	70	21.5	425	55	21.5	...
Philadelphia	Sectional	200	62	14	...	...	...	2300
Baltimore	Basin	504	80	23	450	...	...	...
Baltimore	Floating	220	67	14	...	...	...	2000
Norfolk	Basin	320	60	...	290	60	...	7000
New Orleans	Floating	315	90	16	330	42	16	3000
New Orleans	Floating	220	75	14	230	...	...	1400
New Orleans	Floating	225	75	16	...	...	..	...

JULY 24, 1886. Notice of the Herreschoff launch Henrietta.

Length on water-line, 46 feet by 7 feet 5 inches beam; immersed section, 7½ square feet. Engine, triple-expansion; cylinders, 4, 6½ and 10 inches diameter by 8-inch stroke; steam pressure, 250 pounds. Screw, four-bladed, 28 inches diameter. Weight of vessel in running order, 10,000 pounds. Speed, 20 miles per hour, mean of six trials over measured mile.

AUGUST 7. General plans and specifications of a lake and a light-draught harbor defense boat, designed by Assistant Constructor Gatewood, U. S. N.

SEPTEMBER 4. General plans and specifications of a 19-knot cruiser designed by Armstrong and Mitchell.

SEPTEMBER 18. General plans and specifications of a first-class ironclad for service in open bays and deep channels, designed by Assistant Constructor Gatewood, and recommended by the "Board on Fortifications."

OCTOBER 2, 1886. General description of machinery of U. S. S. Newark.

The Herreschoff launch Henrietta made the trip from Newburg, N. Y. to Sandy Hook, N. J., at 20.8 miles per hour.

OCTOBER 30, 1886. Sketch and description of the boilers of the Naniwa-Kan.

W. F. W.

GIORNALE D'ARTIGLIERIA E GENIO. General orders, decrees, working drawings.

NO. IV, 1886. Artillery percussion fuses.

NO. VI, 1886. Muskets of the various arms, model of 1870.

RIVISTA DI ARTIGLIERIA E GENIO.

APRIL, 1886. Hotchkiss, Nordenfelt, and Armstrong rapid-firing guns. Ballistic tables. Experiments at Bucharest in December and January, 1885–6, with a Mougin turret and a Schumann cupola (complete illustrations). Mining experiments with nitroglycerine. Electric engines at the Turin Exposition. Electric small-arm targets for signaling position of hits.

MAY, 1886. The artillery in the Servo-Bulgarian campaign. Experiments at Spezia in April, 1886, against a Grüson turret plate.

JUNE, 1886. Translation of Gun Foundry Board Report, concluded. Nitroglycerine experiments. Electricity at the Turin Exposition. Armor-plate experiments.

New truck or carriage for heavy weights:

The track is a loosely-jointed periphery outside the wheel, and is joined to the hub by slotted spokes; it is laid in advance and picked up in rear of the wheel by movement of the carriage.

JULY–AUGUST, 1886. The attack and defense of forts. Discovery of an autograph letter of Galileo in regard to the use of mathematics in the military arts. Spezia experiments in April, 1886, with a Grüson plate. Complete maps of the French fortifications on the Italian frontier.

SEPTEMBER, 1886. The use of sugar to prevent scale in boilers.

Supplement to the above publication. "Manuale Regionato del Laboratorio di Precisione," E. Morandotti, Major of Artillery: a pamphlet of 157 pp. and 23 plates, giving details of the use of precise instruments of measurement in artillery workshops.

RIVISTA MARITTIMA.

MAY, 1886. The cruise of the Vettor Pisani (navigation notes, Valparaiso to Callao). The Italian Navy Estimates, continued in numbers for June, July–August, September.

JUNE, 1886. The cruise of the Vettor Pisani (navigation notes, Callao to Guayaquil). Theory of high and low atmospheric pressures.

JULY–AUGUST, 1886. Official statistics of the Italian merchant marine.

On the 31st December, 1885, there were:

Sailing vessels	7111	of	828,819	tons.
Steamers	225	"	124,600	"
Total	7336	"	953,419	"

Personnel of all kinds, 192,046.

For the year before there were:

Sailing vessels	7072	of	848,704	tons.
Steamers	215	"	122,297	"
Total	7287	"	971,001	"

Personnel, 189,162.

SEPTEMBER, 1886. The cruise of the Vettor Pisani (navigation notes, Callao to Panama and the Galapagos Islands). R. C. S.

ASSOCIATION OF ENGINEER SOCIETIES.

Journal for JUNE, 1886, contains: The efficiency of a pipe system for furnishing water to fire-engines. Smoke prevention.

JULY, 1886. President's annual address. Organization of a surveying party. The metre as applied to land-surveying.

AUGUST, 1886. Notes on the Panama Canal, by Chas. D. Jameson, member of the Boston Society Civil Engineers.

A complete account, containing plan and profile of canal, and much statistical information, with many important details. He concludes as follows: "There are no insurmountable obstacles in the way of the completion of the Panama Canal in a few years. . . . The management of the Isthmus has been loose and

disjointed, but it is rapidly improving. Undoubtedly money has been wasted, but no greater percentage than in other large enterprises. The work is being pushed in every direction. Contractors are being held to their contracts, and although no one can state the time when the canal will be finished, still no one can advance the proof why it cannot be finished within the next eight years."

SEPTEMBER, 1886. Rainfall received and collected, etc. Some of the engineering features of Illinois drainage. Foundations of the Garfield Monument. J. W. D.

INSTITUTION OF CIVIL ENGINEERS, LONDON.

VOL. LXXXV, 1885–86, Part III.

VOL. LXXXVI, 1885–86, Part IV. Contains many important and interesting papers, among which are: On the effects of various kinds of liquids, hot and cold, on iron, for preserving it from corrosion. On the employment of iron and steel in construction. The Isthmus of Corinth Canal. Regulation of the Elbe navigation, harbor of Reunion Island. On the rate of detonation in solid and liquid explosives (translated from M. Berthelot). New ordnance material (Captain W. H. Bixby, U. S. A.). Experiments on the steam-engine indicator. Navigation by night on the Suez Canal. A new tubular compass.

LANCASTER PRINT, No. 9. U. S. S. Lancaster, Island of St. Helena, July 11, 1886.

An interesting paper published on board ship and giving important details of ship news, of places visited, with poetic and prose effusions, forming quite a diverting and educational employment beneficial in many ways during a long cruise. J. W. D.

REVUE MARITIME ET COLONIALE.

JUNE, 1886.

In a circular order dated May 20, 1886, and published in this number of the *Revue*, the Minister of Marine directs that all articles intended for publication in the *Revue Maritime et Coloniale* shall be sent directly to the Minister of Marine, instead of being submitted to local commissions of officers. This action is taken on account of a falling off in the number and character of the articles submitted for publication in the *Revue*.

Contents: The Armstrong 6-inch cannon, pattern of 1883. The bursting of the 12-inch cannon of 43 tons on board the Collingwood, May 4, 1886. Quadruple-expansion marine engines.

JULY, 1886. The Italian merchant marine. Launching of the Danish armored vessel Iver-Hvitfeldt. Trial of the 100-ton Armstrong gun against steel plates at Spezia. Inauguration of the high-speed postal service between Paris, Havre and New York.

AUGUST, 1886. The Spanish Navy and its reorganization in June, 1886. Submarine navigation.

SEPTEMBER, 1886. The port of La Ciotat.

The Orlando, English belted-armored cruiser, the first of seven of the same type, was launched August 3, 1886, at the dockyard of Palmer & Co., Yarrow-on-the-Tyne. The principal dimensions of this vessel are: Length, 300 feet; breadth, 56 feet; draught, 20 feet. The total displacement is 5000 tons, with engines of 9000 horse-power. The speed is expected to be 19 knots.

OCTOBER, 1886. Manœuvres of the English squadron in 1886. The English armored vessel Impérieuse. The English gunboats Curlew and Landrail. Armstrong cannons.

UNITED SERVICE GAZETTE.

JULY 31. Description of the new torpedo cruiser Destructor, built by Messrs. Jas. and Geo. Thomson, Clydebank, for the Spanish Navy.

AUGUST 7. Account of recent manœuvres of the French fleet in the Mediterranean.

AUGUST 21. Naval operations at Milford Haven. Fatal accident on board the Opal in firing a salute.

AUGUST 28. Gunnery experiments at Portsmouth.

SEPTEMBER 4. Account of trial of H. M. S. Impérieuse.

SEPTEMBER 11. Report of Ordnance Committee on the bursting of a 12-inch breech-loading gun on board the Collingwood, May 4, 1886.

SEPTEMBER 18. Account of experiments with submarine mines, made at Portsmouth, England, by direction of the Admiralty.

SEPTEMBER 25. Increase of the French Navy.

Dating from 1872, the French have added to their Navy twelve squadron ironclads, seven cruising ironclads, eight coast-defending armor-plated vessels, seven turret ships, nine first-class cruisers and eight of the second class, together with 227 smaller craft, including dispatch and gunboats. There are to be added to the French fleet between this date and the first of the coming year six squadron ironclads, four barbette ships, two turret ships, and three cruisers of the first class. The ironclads will carry guns from 14 to 42 centimetres, which are described as most formidable weapons. It is stated, however, that the cruisers are slow sailers, and that considerable improvement must be made in their engines to fit them for the requirements of modern naval warfare. None of the ironclads can sail 15 knots per hour, and only one of the reputed fast-sailing cruisers can do 18 knots per hour. The French are now turning their attention to the subject of increased speed in their Navy, and much is expected to be done in this direction before the next naval estimates are submitted to the Chamber.

Torpedo experiments of a purely naval character have recently been made at Portsmouth, England. This, it is said, is the first instance of a Whitehead torpedo having been exploded against the hull of a ship. Hitherto their destructive effects have been purely a matter of assumption. The present experiments are calculated to settle any practical questions of attack and defense connected with a torpedo attack which demanded a solution. The experiments were made upon the Resistance, obsolete armorclad, and several things were required to enable her to represent a modern battle-ship attacked under

approximate conditions. The bunkers below the armor-sheif on the port side were made to represent the actual coal defense which is now applied for the protection of the boilers and machinery of a ship-of-war against submarine attack. The bunkers were fitted at Devonport with an iron longitudinal bulkhead, which divided them into two equal compartments. The one contiguous to the skin plating was filled with coal, due precautions being taken against firing by the provision of ventilating tubes. By these means there was a thick protection of coal sandwiched between the inner bunker and the wing passage. The whole port side of the ship was also defended against torpedo attack by Bullivant's service wire nets, boomed out to the distance of 30 feet. This was a distance which previous trials had abundantly proved to be safe against the destructive force of a Whitehead; but the weight of such booms, and the necessary working gear, renders them unhandy, and the main object of the experiment was to ascertain whether the length of the boom could be reduced without danger to the vessel attacked. In actual warfare it is presumed that the burst of a Whitehead would prove fatal to a ship, wherever it came in contact with her; but in this case it was imperative that the Whitehead should hit her, not anywhere, but directly in a certain compartment about 29 feet in length and extending from the keel-flat to the armor-shelf amidships. To insure accuracy, therefore, the vessel was chained stem and stern. The time of high water was chosen for the experiment, so as to avoid the deflective influence of currents. The instrument of execution selected was the old 16-inch Whitehead. The full charge of this old weapon is 91 pounds of gun-cotton, and the full charge for the new 14-inch Whitehead is only 65 pounds. The torpedo was fitted with the new pistol trigger, which is exceedingly sensitive, and explodes the charge upon traversing the meshes of the net. The effective range of the improved Whitehead is 600 yards, but in this instance it was expedient to attack the net defenses of the Resistance at close quarters, and therefore the projectile was discharged by the torpedo vessel when passing the Resistance at a distance of 100 yards. The path of the torpedo through the water was clearly indicated by the air-bubbles which it threw up, and though straight, its progress was undeniably deliberate. The torpedo struck the defenses a little forward of the target, but though the visual force of the explosion was very great, the vessel does not seem to be seriously injured. As soon as the fountain of water which had been thrown up had subsided, it was manifest that the netting had served the intended purpose. The nearest boom had been unshipped from its support, but all the others remained intact. The meshes in the immediate vicinity of the burst had been carried away, but the area of positive destruction was so small that a second attack would have proved just as harmless, unless the torpedo happened to pass through the rent in the defenses made by the first. Two other experiments were made, both with 16-pound cases of gun-cotton, to ascertain the effect of small charges of gun-cotton on the ship itself. As a result the ship appeared to give a list to port, and tugs stood by to pump her out in case she had sprung a leak. She was afterwards found to leak very badly, and the experiments were discontinued.

The torpedo flotilla of the Royal Navy has received, lately, a number of additions by the delivery of a large number of first-class torpedo vessels from the contractors. The Admiralty have issued instructions for these vessels to be at once completed for sea and placed in the first-class reserve, in readiness for sea service. A first-class torpedo boat built by Messrs. Thornycroft, 125 feet long and 16 feet wide, recently made a run down the Solent into the open channel for a distance of forty miles. This run was made with favorable wind and tide in one hour and thirty-eight minutes, and the return trip of forty miles was made against the tide and a strong wind in one hour and fifty-six minutes. The bow-wave thrown up by the snout of the torpedo boat was from 10 to 15 feet high. It is thought that the present shape of the bow and the creation of the wave will affect the accurate discharge of the torpedo from the nose of the vessel, and changes in the mode of discharge are contemplated.

OCTOBER 2. Account of experiments with a new French explosive. A new torpedo invented by Louis Brennan, an Australian civil engineer. The Spanish Navy.

A committee has been ordered to assemble at Portsmouth to consider the whole subject of voice, mechanical and electrical communication between the deck and engine room of men-of-war.

The Unebi, a cruiser constructed at Havre by the Société des Forges et Chantiers for the Japanese Government, recently made her trial trips at Havre and Cherbourg. She attained a mean speed of 18½ knots, one knot over the requirements of the contract. The armament of the Unebi consists of four 24-centimetre guns, seven 15-centimetre guns, and a large number of machine guns. Besides the above armament, the vessel has four torpedo-launching tubes constructed of bronze on the system of M. Canet.

OCTOBER 9. The late Admiral Bedford Pim.

OCTOBER 16. The report of a committee appointed to inquire into the education of naval executive officers.

The dockyard authorities at Portsmouth have received instructions to take the whole of the new Thornycroft torpedo boats in hand, with a view to making them more buoyant, and consequently increasing their speed. At present the boats plunge into every wave they meet, and the weight of the water thus resting at the bows renders the forward torpedo tubes useless, whilst the boats are constantly swamped. The structural alterations will necessitate the removal of the bow tube, and the boat will thus fire only four torpedoes instead of five. Torpedo boat No. 42, one of the latest of the 125-feet first-class boats, is having her tapering snout removed, and the bows brought up level with the deck, the same as the boats of the Yarrow type. When this alteration is completed it is intended to run her in competition with one of White's torpedo boats.

A trial has been made of Nos. 55 and 56, torpedo boats of the first class, built by Thornycroft & Co. Trials over the measured mile gave the following results: No. 55—steam in boilers, 132 pounds; vacuum in condensers, 27 inches; revolutions of engines, 402; speed, 20.35 knots. No. 56—steam in boilers, 132 pounds; vacuum, 27 inches; revolutions of engines, 399; speed, 20.22 knots.

The Impérieuse has returned to England from an experimental cruise to the Mediterranean. Her captain reports that she is a capital steamer, and is so free from vibration that when going at a speed of nine knots, the working of the engines was scarcely appreciable. She proved herself remarkably steady, rolling only 1¼ degrees in the trough of the sea while crossing the Bay of Biscay. She also answered her helm admirably. Her officers are well satisfied with her performances, but they are unanimous in their condemnation of the heavy spars with which she is fitted. They reduce her buoyancy, handicap her engines, and are entirely useless for good in any way. A report to this effect will be made to the Admiralty, and there is every probability of their being superseded by military masts.

B. F. T.

MITTHEILUNGEN AUS DEM GEBIETE DES SEEWESENS.

VOL. XIV, NOS. 6, 7 AND 8. Contain many interesting papers on torpedo boats. The observations at Polar station at Jan Mayen, 1882–83.

ANNALEN DER HYDROGRAPHIE.

PARTS V, VI, VII, VIII, IX. Contain interesting hydrographic and meteorological work of the German Navy.

SCHOOL OF MINES, COLUMBIA COLLEGE, QUARTERLY.

VOL. VII, JULY, 1886. The Rees rifle for military and sporting purposes, by Frank Rees.

This rifle is designed for the purpose of giving to the soldier and sportsman an arm which shall enable him to fire at will consecutive shots with the least possible effort or motion, and without the necessity of taking it down from the shoulder or disarranging the aim while reloading. The model used was fired thousands of times with ball and cartridge. At a recent trial before the officers of the 7th Regiment N. G. S. N. Y., fifteen shots were fired in 8 seconds actual time. J. W. D.

FRANKLIN INSTITUTE JOURNAL.

JULY, 1886. The applications of electricity to the development of marksmanship (O. E. Michaelis, U. S. A.).

AUGUST, 1886. The above concluded. Suggestions towards a simplified system of weather signals, termed the Index Weather-Signal System. A method of designing screw propellers. Christian Hoehle.

SEPTEMBER, 1886. The effect of inertia on the reciprocating parts in modifying the force transmitted to the crank pin (Francis E. Jackson, M. E.).

AMERICAN INSTITUTE OF MINING ENGINEERS.

VOL. XIV, FROM JUNE, 1885, TO MAY, 1886. The microscopic structure of iron and steel. The manufacture of steel castings. A simple apparatus for determining the strength of explosives. The homogeneity of open-hearth steel. Soft steel for boiler plates. The Heine safety boiler. Many other interesting papers.

PROCEEDINGS OF THE INSTITUTION OF MECHANICAL ENGINEERS, LONDON.

MAY, 1886. On the raising of the wrecked steamship, Peer of the Realm.

HYDROGRAPHIC WORK OF THE UNITED STATES NAVY. BY LIEUTENANT A. B. WYCKOFF, U. S. N.

TRANSACTIONS OF THE TECHNICAL SOCIETY OF THE PACIFIC COAST. MAY, 1886.

JOURNAL OF THE ASSOCIATION OF ENGINEERING SOCIETIES.

Pile-driving, by E. H. Beckler. The work of the United States Testing Machine at Watertown Arsenal, by J. E. Howard.

ASSOCIATION PARISIENNE DES PROPRIETAIRES D'APPAREILS À VAPEUR. 12e Bulletin.

The above-mentioned publications are kept in the library of the Naval Institute. Members can obtain them for reference by applying to the Secretary.

SPECIAL NOTICE.

NAVAL INSTITUTE PRIZE ESSAY, 1887.

A prize of one hundred dollars and a gold medal is offered by the Naval Institute for the best Essay presented, subject to the following rules:

1. Competition for the Prize is open to all members, Regular, Life, Honorary, and Associate, and to all persons entitled to become members, provided such membership be completed before the submission of the Essay. Members whose dues are two years in arrears are not eligible to compete for the Prize until their dues are paid.

2. Each competitor to send his essay in a sealed envelope to the Secretary and Treasurer on or before January 1, 1887. The name of the writer shall not be given in this envelope, but instead thereof a motto. Accompanying the essay a separate sealed envelope will be sent to the Secretary and Treasurer, with the motto on the outside and writer's name and motto inside. This envelope is not to be opened until after the decision of the Judges.

3. The Judges to be three gentlemen of eminent professional attainments (to be selected by the Board of Control), who will be requested to designate the essay, if any, worthy of the Prize, and, also, those deserving honorable mention, in the order of their merit.

4. The successful essay to be published in the Proceedings of the Institute; and the essays of other competitors, receiving honorable mention, to be published also, at the discretion of the Board of Control; and no change shall be made in the text of any competitive essay, published in the Proceedings of the Institute, after it leaves the hands of the Judges.

5. Any essay not having received honorable mention, to be published only with the consent of the author.

6. The subject for the Prize Essay is, *The Naval Brigade: Its Organization, Equipment, and Tactics.*

7. The successful competitor will be made a Life Member of the Institute.

8. In the event of the Prize being awarded to the winner of a previous year, a gold clasp, suitably engraved, will be given in lieu of a gold medal.

By direction of Board of Control.

JNO. W. DANENHOWER,

Lieutenant, Secretary and Treasurer.

ANNAPOLIS, MD., *January* 1, 1886.